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[THIRD SERIES.]

ART. I.—*On the Inequalities in the Moon's Motion produced by the Oblateness of the Earth;* by Professor J. N. STOCKWELL.

HAVING given in the November number of this Journal, an account of a secular inequality in the moon's motion, arising from the oblateness of the earth, I propose to give, in the present number, a somewhat detailed account of the principal periodic inequalities in the motions of the moon arising from the same cause. And I would here state that a careful study of the effect of the earth's ellipticity on the motions of the moon, through the medium of analysis, has presented some of the most curious and interesting cases of perturbation to be found in physical astronomy. The principal inequalities to which I would call attention, are chiefly remarkable as being the product of a number of important, though mutually antagonistic forces, the resultant of which, on any given coördinate of the moon, is of far less importance than would arise from the undisturbed operation of any one of the constituent forces; and I do not remember any cases of perturbation in the moon's motion, arising from the sun's attraction, in which the effect of the force on any given coördinate is so completely neutralized by the action of the same force on some of the other elements of motion. The analysis which I have employed has presented the results in such shape as to show: *First*, the separate effect of the earth's oblateness on the motions of the moon; and *Second*, the combined effect resulting from the earth's figure and the sun's attraction. It is from these two points of view that I shall now consider the subject.

In the paper referred to above, it was shown that the motion of a body moving in a circular orbit in the plane of the equator would be uniform; and that the motion in a circular orbit which was inclined to the equator would be subject to inequalities, the magnitude of which would depend on the inclination of the orbit to the equator. Now the ecliptic is inclined to the equator at an angle of 23° 27′, and the moon's orbit is inclined to the ecliptic at an angle of 5° 8′. If, then, the ascending node of the moon's orbit is at the vernal equinox, the inclination of the moon's orbit to the equator will be 28° 35′; and she will attain to that degree of declination twice during each sidereal revolution. In this position of the node, the inequalities of the earth's attraction on the moon attain their maximum values. Suppose, now, that the ascending node is at the autumnal equinox. It is evident that the inclination of the orbit to the equator will be only 18° 19′, and that she will only reach that declination twice during each revolution. The inequalities of the earth's attraction on the moon, in this last position of the node, will evidently be at their minimum values. As the node passes from one equinox to the other, it is plain that the inequalities of the earth's attraction on the moon pass through all the changes of value to which they are at any time subject. Now the moon's node makes a complete revolution on the ecliptic in a period of 18·6 years; consequently all the inequalities of the moon's motion arising from the oblateness of the earth will effect a complete restoration in that period. Since the motion of the moon's node is caused by the sun's attraction, we must, in the calculation of the separate effect of the spheroidal form of the earth on the moon's motion, neglect the sun's attraction and regard the elements of the moon's orbit as constant, except so far as they are affected by the form of the earth itself. From these general considerations it follows that the moon's declination, on which the inequalities of the earth's attractive force depends, is affected by two conditions: namely, the longitude of the moon and the longitude of the node. I shall therefore in the present paper consider only the inequalities which depend on these two elements, either separately or in combination.

In the calculations which I have made, the oblateness of the earth has been taken as $\frac{1}{300}$; and in the few equations which are given, the symbols have the following significations: a and nt denote the moon's mean distance and mean longitude; v and θ denote the moon's true longitude and latitude. γ and ☊ denote the inclination and longitude of node of moon's orbit; ϵ denotes the obliquity of the ecliptic, and D denotes the mean radius of the earth; ρ and φ denote the oblateness of the earth, and the ratio of the centrifugal force to the gravity at

the earth's equator; R denotes the disturbing function; and δ placed before a quantity denotes the variation of that quantity arising from the oblateness of the earth. I also put for brevity

$$\beta = \{\rho - \tfrac{1}{2}\varphi\}\frac{D^2}{a^2}\sin\varepsilon\cos\varepsilon. \tag{1}$$

I now give the equations which express the variations of the elements and coördinates of the moon, and which are independent of the sun's action. In the first place I find that the position of the node and inclination of the orbit are affected by the following inequalities:

$$\delta\Omega = \tfrac{1}{2}\frac{\beta}{\gamma}\sin(2nt - \Omega) = +0''\cdot185\sin(2nt - \Omega), \tag{2}$$

$$\delta\gamma = \tfrac{1}{2}\beta\cos(2nt - \Omega) = +0''\cdot0165\cos(2nt - \Omega). \tag{3}$$

These two inequalities give rise to the following inequality in the moon's latitude:

$$\delta\theta = -\tfrac{1}{2}\beta\sin nt = -0''\cdot0165\sin nt. \tag{4}$$

But I find that the direct action of the earth on the moon produces the following inequality:

$$\delta\theta = +\tfrac{1}{2}\beta\sin nt, \tag{5}$$

The sum of these two inequalities gives $\delta\theta = 0$; whence it follows that there is no equation of the above form in the moon's latitude arising from the oblateness of the earth. In other words, the figure of the earth does not cause the moon to depart from the plane of the great circle in which its orbit is situated.

The above values of $\delta\Omega$ and $\delta\gamma$ also give the following inequality in the moon's longitude:

$$\delta v = +\tfrac{1}{4}\beta\gamma\sin\Omega = +0''\cdot00074\sin\Omega). \tag{6}$$

The direct action of the earth on the moon produces the following inequalities in the longitude:

$$\left.\begin{aligned} \delta v &= \tfrac{1}{12}\beta\tan\varepsilon\sin 2nt - \tfrac{1}{12}\beta\gamma\sin(2nt - \Omega) \\ &= +0''\cdot0012\sin 2nt - 0''\cdot00025\sin(2nt - \Omega). \end{aligned}\right\} \tag{7}$$

These inequalities in longitude are so excessively small as to be entirely insensible. The sum of the coefficients in these three terms of δv amounts to only $0''\cdot0022$, a quantity not exceeding *fourteen feet* if measured on the moon's orbit. From this calculation it follows that, if the moon were entirely free from solar disturbance, the effect of the oblateness of the earth on its motions would be so small that it would never be detected by observation.

Let us now examine into the effect of a combination of solar disturbance with that arising from the earth's oblateness. Since we have supposed the moon's orbit to be circular, it is

evident that the earth's attraction on the moon is at a maximum whenever the moon is in the equator, or twice during each revolution of the moon. We will now suppose that the longitude of the moon's node is 90°, and examine into the consequences that must take place while it retrogrades through a semi-circumference, or from +90° to −90°.

When ☊ = +90°, the moon's orbit intersects the equator at a distance of 12° 45′ to the eastward of the equinox: and since the node retrogrades on the ecliptic about 1° 27′ during a sidereal revolution of the moon, it follows that the moon will arrive at the equator at a point a little to the westward of its previous crossing. In other words, the moon will make a complete revolution with respect to the center of force in a period somewhat shorter than the sidereal revolution. At the end of 9·8 years the longitude of the node will be −90°, and the orbit will intersect the equator at a distance of 12° 45′ to the westward of the equinox. Now the moon performs 124·3256 sidereal revolutions while the node is retrograding through an arc of 180°. But 124·3256 sidereal revolutions correspond to 124·3256 revolutions +23° 21′ with respect to the equator. Whence it appears that while the node is retrograding from +90° to −90°, the time of revolution with respect to the equator is shorter on an average by 20^{m} 32^{s} than the sidereal revolution. It is plain that while the node is retrograding from −90° through the autumnal equinox to +90°, the point of intersection of the orbit and equator will advance from −12° 45′ to +12° 45′, and the time of revolution of the moon with respect to the equator will exceed the time of the sidereal revolution by the same amount that it fell short of that quantity while retrograding through the other half of the orbit. It is also plain that the inclination of the orbit to the equator increases while the equatorial node is approaching the vernal equinox, at which point it is a maximum, and diminishing while it is receding from it. The constant retrograde motion of the ecliptic node of the moon's orbit, therefore, gives rise to a merely oscillatory motion of the equatorial node; and it is this pendulum-like motion of the equatorial node that gives rise to a number of inequalities in the moon's motion which I now proceed to consider; observing that the inequalities which are produced while the node is advancing are fully compensated by means of the retrograde motion which follows.

I now give the values of the perturbations of the elements and coördinates which I have obtained, as resulting from the motion of the moon's node, which is produced by the sun's attraction. I find

$$\left.\begin{aligned}\delta\Omega &= -\frac{\beta}{\alpha\gamma}\sin\Omega = +91''\cdot324\sin\Omega\\ \delta\gamma &= +\frac{\beta}{\alpha}\cos\Omega = -8''\cdot2233\cos\Omega\end{aligned}\right\}; \tag{8}$$

α being the ratio of the motion of the node to the moon's mean motion. These inequalities of the elements give rise to the following inequality in the latitude:

$$\delta\theta = \frac{\beta}{\alpha}\sin nt = -8''\cdot2233\sin nt. \tag{9}$$

This is exactly the same as LaPlace and subsequent investigators would have obtained had they used the same value of the earth's ellipticity. This inequality in the moon's latitude is equivalent to the supposition that the moon's orbit, instead of moving on the plane of the ecliptic with a constant inclination, moves, with the same condition, upon a plane passing always through the equinoxes, between the ecliptic and equator and inclined to the ecliptic by an angle which is equal to $\frac{\beta}{\alpha}$, as LaPlace has remarked.

I have not, however, been equally fortunate in reproducing the value of the inequality in the moon's longitude, which LaPlace and later investigators have obtained. I find as directly resulting from the motion of the moon's node, the following inequality in the longitude:

$$\delta v = -\frac{\beta}{\alpha^2}\gamma\sin\Omega = -184''\cdot3\sin\Omega. \tag{10}$$

But the preceding inequality in latitude gives rise to the two following inequalities in the longitude:

$$\left.\begin{aligned}\delta v &= +\frac{\beta}{\alpha_2}\gamma\sin\Omega - \tfrac{1}{2}\frac{\beta}{\alpha}\gamma\sin(2nt-\Omega)\\ &= +184''\cdot3\sin\Omega + 0''\cdot37\sin(2nt-\Omega)\end{aligned}\right\}. \tag{11}$$

The first of these two inequalities derived from the perturbations in latitude exactly cancels the preceding inequality in the longitude which is produced directly from the retrograde motion of the node; and we have as the resultant of the two forces,

$$\delta v = -\tfrac{1}{2}\frac{\beta}{\alpha}\gamma\sin(2nt-\Omega) = +0''\cdot37\sin(2nt-\Omega). \tag{12}$$

I find, however, that the radius vector of the moon's orbit is affected by the inequality

$$\delta v = 3a\beta\gamma\cos\Omega, \tag{13}$$

and this produces the following inequality in the longitude,

$$\delta v = -6\frac{\beta}{\alpha}\gamma\sin\Omega = +4''\cdot443\sin\Omega, \tag{14}$$

while LaPlace found

$$\delta v = -\tfrac{19}{2}\frac{\beta}{\alpha}\gamma \sin \Omega = +\ 7''{\cdot}03 \sin \Omega. \tag{15}$$

If, in the development of the inequalities depending on the oblateness of the earth we carry on the approximations so as to include terms of a higher order depending on the eccentricity and inclination of the orbit, we shall find two equations of sensible magnitude, having the same arguments as two empirical equations discovered by Airy about a third of a century ago. These equations depend on the arguments $nt - \omega - \Omega$, and $nt - \omega + \Omega$, in which ω denotes the longitude of the perigee. These arguments have periods of 27·4432 days, and 27·6661 days, respectively. The equation depending on the first of these arguments seems also to have been independently discovered quite recently, as an empirical equation, by Professor Newcomb, who attributes it to the attraction of some of the planets. From some calculations which I have made I am led to suspect that each of these equations has a value amounting to quite a large fraction of a second of arc; and I call attention to them here as being worthy of a more thorough investigation by astronomers.

It is but proper to add in this connection, that the mean motions of the perigee and node of the lunar orbit are affected by the oblateness of the earth; and are also affected by secular equations arising from the diminution of the obliquity of the ecliptic. The motions of the perigee and node which I have obtained agree in value with those obtained by LaPlace. I have therefore succeeded in reproducing exactly, by my method of computation, all the inequalities in the motions of the moon arising from the oblateness of the earth, which LaPlace discovered nearly a century ago, with the exception of the equation in longitude. The coefficient of LaPlace's equation exceeds the value which I have obtained, in the ratio of 19 to 12; and it has been a matter of surprise that two very dissimilar methods of computation should give so many results identically the same, and leave only a single one discordant. This has led me to make a critical examination of every step of LaPlace's calculation of this equation; and this examination has developed the fact that LaPlace has, in this instance, departed widely from the requirements of his own formulæ and methods; and that a correct calculation by his method gives a result identically the same as I have found by my own. I shall therefore now give the several steps of this examination, believing that it will not be without interest to the readers of this Journal. In this investigation it has been found convenient to use Bowditch's translation of the *Mécanique Céleste*,

as the facilities for referring to any part of the work by means of the marginal numbers are much better than in the original. I shall also change the notation somewhat, putting ϵ for λ, and a for $g-1$ in some cases, and shall also put $f=1$. The numbers inclosed in brackets refer to the corresponding marginal numbers of the *Mécanique Céleste*.

The expression of the force R, [5362] becomes by using the value of β, which is given by equation (1) of this paper, and putting $f=1$,

$$R = 2\frac{a^2\beta}{r^3}s\sin v. \tag{16}$$

In this equation s denotes the tangent of the moon's latitude. This value of R gives the following values of the partial differential coefficients,

$$\left(\frac{dR}{dr}\right) = -6\frac{a^2\beta}{r^4}s\sin v, \tag{17}$$

$$\left(\frac{dR}{dv}\right) = \quad 2\frac{a^2\beta}{r^3}s\cos v, \tag{18}$$

$$\left(\frac{dR}{ds}\right) = \quad 2\frac{a^2\beta}{r^3}\sin v. \tag{19}$$

The equation which determines the value of δv, is [5367], namely,

$$d\delta v = 3\frac{dt^2}{r^2 dv}\int \mathrm{d}R + 2\frac{dt^2}{r^2 dv}r\left(\frac{dR}{dr}\right); \tag{20}$$

and the value of dR is

$$\mathrm{d}R = \left(\frac{dR}{dr}\right)dr + \left(\frac{dR}{dv}\right)dv + \left(\frac{dR}{ds}\right)ds. \tag{21}$$

The value of s is given by the equation [5376], namely,

$$s = \gamma\sin(gv - \Omega), \tag{22}$$

in which I have changed θ to Ω, in order to avoid confusion of symbols. Now (22) gives by differentiation

$$ds = g\gamma\, dv\cos(gv - \Omega). \tag{23}$$

If we neglect the eccentricity of the orbit we shall have $dr=0$, consequently the term $\left(\frac{dR}{dr}\right)dr$ will vanish from the value of $\mathrm{d}R$. Now substituting the value of s, (22) in (18), and multiplying (19) by ds, which is given by (23), we shall get,

$$\left(\frac{dR}{dv}\right)dv = a^2\frac{\beta}{r^3}\gamma\, dv\,\{\sin(gv+v-\Omega) + \sin(gv-v-\Omega)\}. \tag{24}$$

$$\left(\frac{dR}{ds}\right)ds = a^2 g\frac{\beta}{r^3}\gamma\, dv\,\{\sin(gv+v-\Omega) - \sin(gv-v-\Omega)\}. \tag{25}$$

If we substitute these values in equation (21), and retain only the term depending on the angle $(gv - v - \Omega)$, it will become

$$dR = -a^2 \frac{\beta}{r^3} \gamma (g-1)\, dv \sin (gv - v - \Omega.) \tag{26}$$

This gives by integration

$$\int dR = a^2 \frac{\beta}{r^3} \gamma \cos (gv - v - \Omega). \tag{27}$$

If we substitute the value of s in equation (17) and multiply by r it will become

$$r\left(\frac{dR}{dr}\right) = -\, 3a^2 \frac{\beta}{r^3} \gamma \cos (gv - v - \Omega). \tag{28}$$

Substituting (27) and (28) in (20), it becomes

$$d\delta v = -\, 3a^2 \frac{\beta}{r^2 dv} \frac{\gamma}{r^3} \cos (gv - v - \Omega). \tag{29}$$

This is the same as LaPlace has given in [5368].

But LaPlace has given a second term depending on the same argument. This second term arises from the variation of the sun's disturbing force which is due to the variation of the moon's latitude produced by the earth's oblateness. The expression of this force is given in equation [5372] and is as follows:

$$\delta R = \tfrac{3}{2} m' u'^3 r^2 s\delta s. \tag{30}$$

I shall now show that this value of δR is the same as the value of R given by equation [5362], except that it has a contrary sign.

According to [5374] we have

$$\tfrac{3}{2} m' u'^3 r^2 = \tfrac{3}{2} \frac{m^2}{r} = 2 \frac{g-1}{r}, \tag{31}$$

and if we substitute this in (30) or [5372] it becomes

$$\delta R = 2 \frac{g-1}{r} s\delta s. \tag{32}$$

And if we substitute in this, the value of δs given by [5376], which reduced to the notation of this article is

$$\delta s = -a^2 \frac{\beta}{(g-1) r^3} \sin v, \tag{33}$$

it becomes

$$\delta R = -\, 2a^2 \frac{\beta}{r^4} \sin v. \tag{34}$$

This is the same as (16) or [5362] except that it has a contrary sign. This force is therefore the reaction of the force expended by the sun in giving motion to the moon's node, which in turn produces the inequality in the moon's latitude.

But in this second part of his work LaPlace seems to have committed a grave oversight, for he has treated his equation [5372] in the construction of [5373], as though δs were constant; whereas it is a function of both r and v, according to

[5376] which he afterwards uses in his reductions. However, as I have shown above that equation [5372] is the same as [5362], and has a contrary sign, it is unnecessary to pursue this part of the inquiry further, since it is evident that the whole value of δv must be derived from the value of R in [5362].

LaPlace has given the complete value of $d\delta v$ corresponding to the plane of the orbit, in [5379]; and he gives a correction in [5385] to reduce it to the plane of the ecliptic. It is apparent, however, that this correction does not exist, for LaPlace has shown in [923'] etc., where this subject is first investigated, that this correction is of the order of the square of the disturbing force; and as terms of that order have not been considered, it is evident that the value of that correction which he has given in [5385] is erroneous.

To complete this subject, it now remains to be shown that the value of R in equation [5362] gives the value of $d\delta v$ twice as great as LaPlace has found in [5368]. For this purpose I would remark that the value of $d\delta v$ given by means of [5367], is the correction to the *disturbed mean longitude*, and not to the undisturbed mean longitude. In order to correct for this condition it is necessary to add the term $3\frac{dt^2}{r^2dv}\int \mathrm{d}R$ to the first member, and this cancels the same term in the second member, thus leaving the correction to the *undisturbed mean longitude*, or δv equal to

$$\int 2\,\frac{dt^2}{r^2dv}\,r\left(\frac{dR}{dr}\right).$$

This will be apparent from the considerations given in § 54 of Book II of *Mécanique Céleste*, from which it appears that the function $\mathrm{d}R$ has a term of the form $\sin(\alpha t+\beta)$, in which α is very small, and gives by a double integration α^2 as a divisor; and LaPlace has shown in [1070'] that for this case we must increase the mean longitude by the quantity $3\frac{a}{\mu}\int ndt\int \mathrm{d}R$, which is equal to $3\int\frac{dt^2}{r^2dv}\int \mathrm{d}R$, or to the first term of the second member of equation [5367]. It therefore follows that the complete value of $d\delta v$ will be given by the equation

$$d\delta v = 2\,\frac{dt^2}{r^2dv}\,r\left(\frac{dR}{dr}\right). \qquad (35)$$

and if we substitute the value of $r\left(\frac{dR}{dr}\right)$ given by [5365] it becomes equal to twice equation [5368], or identically the same as I have obtained by an entirely different method.

Cleveland, Ohio, Oct. 29, 1879.

ART. II.—*An Electro-Dynamometer for Measuring Large Currents;* by WALTER N. HILL, S.B. (Harvard), Chemist, U. S. Torpedo Station, Newport, R. I.

THE use of electric machines of large size, for the generation of currents of great strength, has become extensive and promises to increase materially. In connection with this, the best mode of measuring the currents obtained is a matter of much importance, as well as one of some difficulty.

Probably at the present time, the method by the use of the galvanometer—heavily shunted—and that involving the determination of the heat developed in the circuit are the most used, but they are objectionable from their inconvenience, complexity and liability to many errors.

The method employing the electro-dynamometer is to be preferred for many reasons and it has also the advantage of being applicable to to-and-fro currents, as well as to those in one direction.

Weber's form of the electro-dynamometer is an instrument which, as Clerk-Maxwell says, "is probably the best fitted for absolute measurements." In this, one coil is suspended within another, the suspension being a fine wire through which the current is led to the suspended coil. It is therefore only suitable for the direct measurement of very small currents. If currents of greater strength are employed, the suspending wire is heated and elongated. It is consequently necessary in measuring powerful currents with Weber's electro-dynamometer to use very large shunts.

As has been pointed out by Trowbridge, it is very desirable to avoid the use of shunts, since the entire resistance of the circuit is of the same order of magnitude as the shunt. In general, a method depending upon the measurement of a *very small proportional part* of the whole current is objectionable, since very great accuracy is necessary and errors of observation are exaggerated.

Trowbridge has designed an electro-dynamometer through which large currents may be transmitted and directly measured. (Proc. Am. Acad. Arts and Sci., Oct. 9, 1878). It consists essentially of two large fixed coils made from copper bands, between which is suspended, from a torsion head, a small coil—the whole so arranged that by means of mercury connections the entire current will traverse the smaller coil, as well as the larger ones. A small mirror is attached to the deflecting coil and by means of a telescope and scale, the deflections may be read. In practice, however, Trowbridge found that the better mode of observation was to bring back, by the torsion head,

the coil to the zero point determined by the telescope, scale and mirror. This instrument gives good results. Measurements can be made more rapidly with it than by the galvanometric method and without shunting.

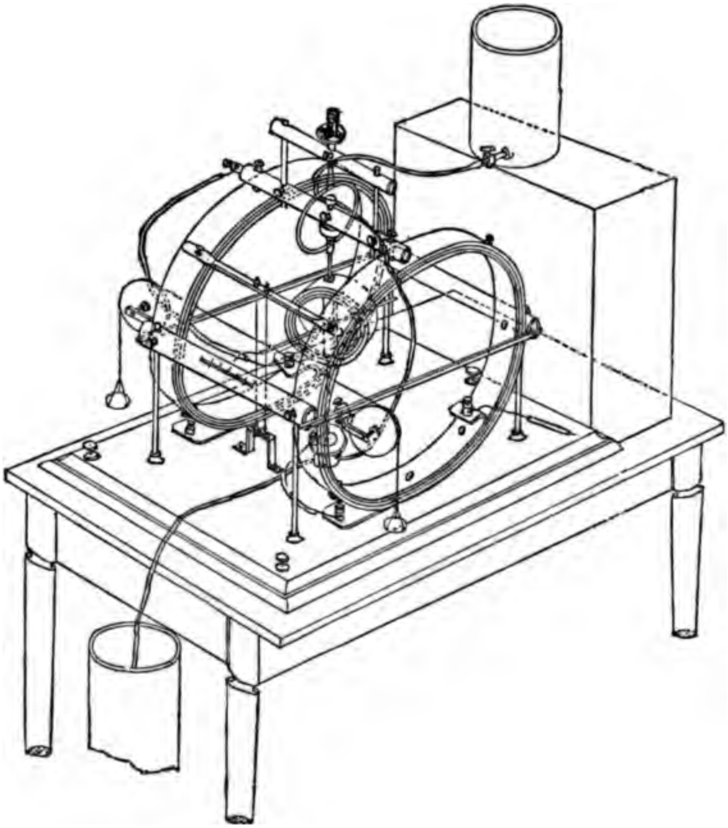
During the past year, the writer has been experimenting at the U. S. Torpedo Station with an electro-dynamometer, differing from Trowbridge's in the manner of observing or determining the deflective power of the current. In its general plan, including the arrangement for taking the entire current to be measured, it follows Trowbridge's form.

Fig. 1 is a general view of the instrument. Figs. 2 and 3 show the details of the suspended coil. The large fixed coils are made of copper ribbon 37^{mm} wide by $1\frac{1}{2}^{mm}$ thick. The turns are separated by ebonite rings and fastened together by brass rods and screw-nuts insulated by ebonite. The metal frame-work is similarly insulated from the coils. The suspension arrangement is placed on the top of the fixed coils and insulated from them. The upper cylinder which carries the suspension pulley is capable of vertical motion and can be fixed in any position by set-screws.

The deflecting coil (figs. 2 and 3) is made of copper ribbon 49^{mm} wide by $1\frac{1}{2}^{mm}$ thick, fastened with insulated rivets. In the center of the coil and parallel with it, is a light brass rod or pointer. A copper rod in connection with the outer end of the coil has an iron or nickel-plated point, which dips in mercury contained in a double-walled metal cup, B, on the base-board. A similar rod from the inner extremity of the coil, ends in an iron or nickel-plated cup, C, containing mercury. By means of a ring, the coil is hung directly under the metal cylinder, D, which lies centrally across the tops of the large coils. Through an opening in the center of this cylinder, passes a hollow metal plunger, A, which dips in the mercury contained in the cup of the small coil. The suspension is of fine sewing silk, waxed or shellaced. The thread passes over a little pulley, E, above, with both parts parallel or nearly parallel and close together. As represented in fig. 1, the large coils are connected "tandem." The current would enter the left hand coil at the screw-post in front; from the other end of this coil, a thick wire leads to the metal cylinder lying across the large coils, making connection with the small coil by its mercury cup, and from the mercury cup below a wire passes to one end of the other large coil. In order to prevent heating of the mercury connections, the plunger A is hollow and the cup B is double walled, so that a stream of cold water may be sent through them from the jar placed upon the stand above the instrument, the necessary connections being made by means of small rubber tubes.

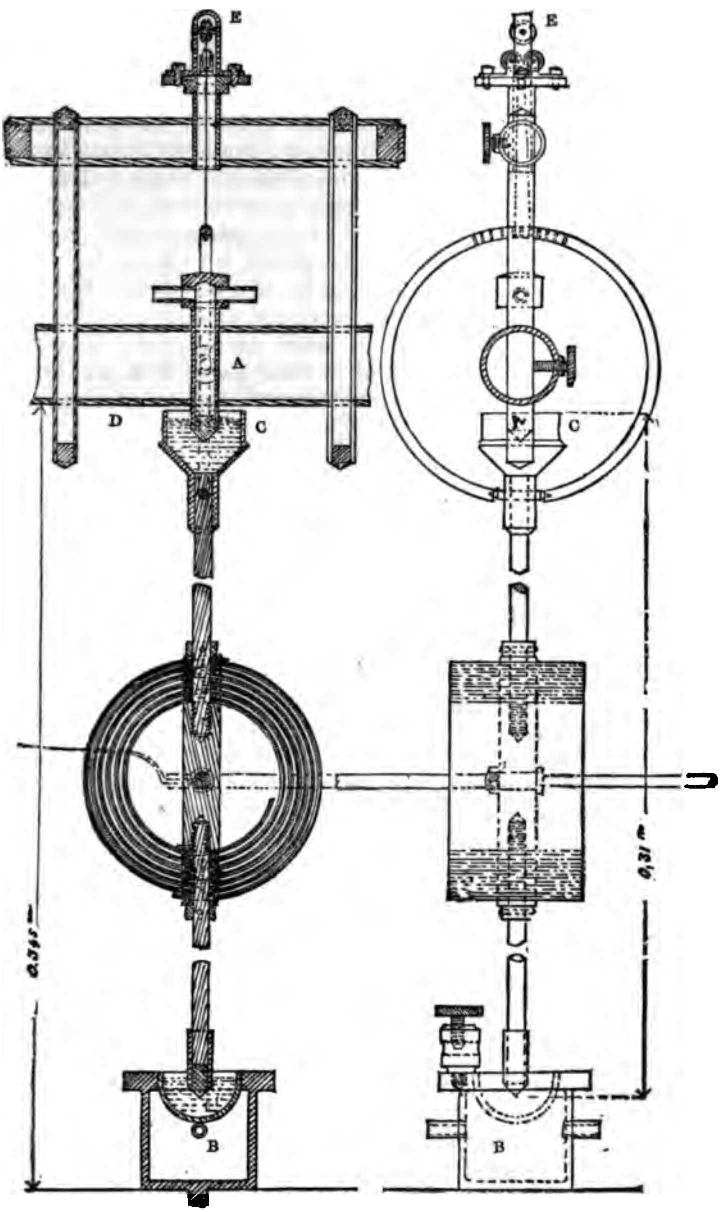
When the current passes, the suspended coil is powerfully deflected but its actual movement is limited by a vertical wire stop. There are two of these stops, one on each side of the pointer-rod of the suspended coil. They are about 15^{mm} apart, so that the rod can move but 7·5^{mm} on either side the center. To the pointer-rod are attached on opposite sides, two silk threads which lead over pulleys on the side bars to small pans, one on each side of the instrument. (Fig. 1). The pulleys are

1.



62^{mm} in diam. and have scores for the threads. They are light, nicely balanced and turn on hardened steel pivots. When deflection has occurred, weights are added to the pan on the side opposite until the pointer-rod returns to the starting point. If the weight added is too great, the pointer-rod is drawn against the other wire stop. Weights may then be removed or put into the opposite pan, until the right point is attained.

2. 3.



The weight employed exactly balances the magnetic force. The mode of observing the zero point was not quite satisfactory. It was originally intended to use a vertical wire stop, the pointer-rod to be drawn back until it just touched the wire, but it was found that it was difficult to hit this point exactly. Finally, a scale was marked on the cylinder in front of the instrument (fig. 1) and a pointer of aluminum wire fastened to the rod, so that it would traverse the scale. This plan worked well and with more careful construction will doubtless be sufficient, but a better method is probably one suggested by Captain F. M. Ramsay, U. S. N., which is to use a light vertical pointer hanging over the scale on the base. When adjusted, the pointer-rod of the suspended coil should just touch the vertical pointer when the latter is at zero. The exact return to the same point would be easily seen, as a small excess of weight would cause a movement of the pointer over the scale.

The pans are of the same weight and the threads by which they are hung, are fibers of unspun silk. The friction of the pulleys is very small, and would be trifling if they were made with jewelled bearings. Also, one balances or nearly balances the other, so that practically their friction may be neglected, although allowance might be made for it if extreme nicety were aimed at. It must be remembered that the actual observation is made when the coil is in the zero position, the weight taken being that required to *balance* the deflecting force. The movement of the pulleys is then very slight and the weight acts exactly at right angles to the pointer-rod.

For the measurement of the large currents derived from dynamo-electric machines, minuteness is not demanded, since the variations due to fluctuations in the currents, alterations in resistance, etc., are much greater than the limits of observation in such an instrument as this. Thus in practice, when attempting to ascertain the current obtained per horse power expended, we have to note the velocity of the machine and the indications of the power dynamometer, together with the current measure, as nearly as possible at the same moment. Quickness and simplicity of working, together with strength and compactness are required in the electro-dynamometer, and this instrument possesses these practical advantages, while it is capable of a good degree of accuracy.

The writer has employed it at the U. S. Torpedo Station for measuring currents of from 20 to 80 webers. It is a good working instrument and gives uniform results. It was made for experimental trial and is defective in certain respects. With some improvements in construction, it would be a little more sensitive, particularly to comparatively small currents. The

suspension arrangement is supported on the large coils and lacks steadiness. It should be placed upon a distinct standard. A support for the deflecting coil when not in use, should be added and an arrangement for centering it quickly.

Theory of the Instrument.—The expression for the strength of current is very simple. The weight found is that required to balance the deflective force and is observed at zero, so that the earth's and local attractions are avoided, nor does the torsion of the suspension enter. Let

S = strength of current in webers.
w = weight used, in milligrams.
l = length of weight-arm or distance from point where weight acts, to center of system.
G = constant of large coils.
g = constant of small coil.
C = constant of instrument or length of magnetic arm.

By the theory of the electro-dynamometer, the force acting to deflect is represented by the expression $\frac{2\pi n}{r} \times g \times S^2$, in which $\frac{2\pi n}{r}$ is the constant of the large coils or G, and g the constant of deflecting coil. This force acts with the arm C, and is balanced by the weight acting with the arm l. Hence

$$S^2 = \frac{lw}{CGg}.$$

The coils being large, G and g are readily ascertained from measurement. l is a known distance. C is the constant of the instrument and must be specially determined. With the instrument in question, C was found by running the same currents through it and through Trowbridge's dynamometer, the constant of which was accurately known. C, l, G, and g being known, it is evident that from weight found, the current may be obtained with little calculation. Or, a table may be drawn up from which the values desired can be obtained by inspection.

With this instrument, which has many turns in the fixed and movable coils, the deflections are powerful, requiring weights to balance them large enough to give sufficient sensitiveness.

The following table shows the weights required for currents from 21 to 30 webers, and from 91 to 100 webers, with my instrument as arranged.

S. webers.	*w.* grm.	diff.	S. webers.	*w.* grm.	diff.	S. webers.	*w.* grm.	diff.	S. webers.	*w.* grm.	diff.
21	·58		26	·89	·70	91	10·92		96	12·15	·25
22	·64	·06	27	·96	·07	92	11·16	·24	97	12·41	·26
23	·70	·06	28	1·03	·07	93	11·40	·24	98	12·66	·25
24	·76	·06	29	1·11	·08	94	11·65	·25	99	12·92	·26
25	·82	·06	30	1·19	·08	95	11·90	·25	100	13·19	·27

This table shows whole webers only, which, for some purposes, would be sufficient, but the subdivisions can be supplied if desired. Thus, we have between 59 and 60 webers:

S. webers.	*w.* grm.	S. webers.	*w.* grm.
59·	4·590	59·6	4·680
59·1	4·605	59·7	4·700
59·2	4·620	59·8	4·715
59·3	4·635	59·9	4·730
59·4	4·650	60·	4·750
59·5	4·665		

If a set of weights arranged for ordinary balance use is employed, it would be better to draw up the table to correspond, making the difference between any two contiguous terms of *w*, the smallest weight taken. Thus my instrument indicates 10^{mg}, which gives sufficient minuteness.

It is plain that a set of weights could be made which would represent webers current, making any calculation unnecessary. This would be often convenient, if much work was to be done.

For technical purposes, when an approximate measure is sufficient, a set which would not be too cumbrous might have brass weights for differences of five webers, and platinum ones for intermediate figures. Thus, between 30 and 40 webers:—

Principal weights.		Minor weights.			S.
1·185 grm.	1 1	·085 grm. ·085	2	·170 grm.	30 webers.
1·615	1	·095 ·095	2	·195	35
2·110	1				40

With this instrument, I have worked with currents as small as 10 webers, but it is not sensitive enough for such use. Above 20 webers, it operates satisfactorily. Greater nicety of construction would confer greater sensitiveness to small weights, but it is evident that this form of the dynamometer is particularly suitable for *large* currents.

We have $S : S' :: \sqrt{w} : \sqrt{w'}$,

That is, as the currents increase, the corresponding weights increase more rapidly and greater accuracy and minuteness are attained. Between 21 and 22 webers, the difference of weight is ·06 grm., and between 99 and 100 ·27 grm.

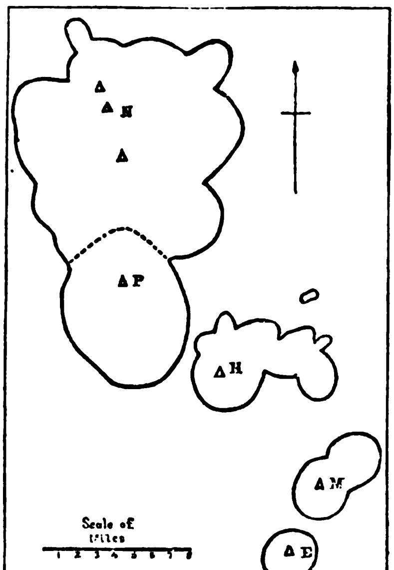
My best thanks are due to Prof. John Trowbridge, of Harvard University, for advice and the use of his apparatus.

U. S. Torpedo Station, Newport, R. I., October 25, 1879.

Art. III.—*Gilbert's Report on the Geology of the Henry Mountains.**

Mr. Gilbert presents much that is new to Geology in his account of the Henry Mountains. These mountains—so named by Mr. Powell in honor of Professor Joseph Henry—are situated in Southern Utah, about the meridian of 110° 45′, and the parallel of 38°. They are an irregular group—not a range—of five mountains, the highest about 5,000 feet above the arid plateau at their base, and 11,000 feet above the sea. It is stated that although much cut up by vallies of erosion, they still show, to some extent, by their forms, but chiefly by the dip of their beds, that they were originally mammiform bulgings of the strata of the region, or groups of such bulgings. The accompanying figure is a ground-plan of the Henry Mountains: N, Mt. Ellen; P, Mt. Pennell; H, Mt. Hillers; M, Mt. Holmes; E, Mt. Ellsworth; it represents N (Mt. Ellen), P (Mt. Pennell), H (Mt. Hillers) as each a group; M (Mt. Holmes) as a combination of two domes, and E (Mt. Ellsworth) alone as single. The single bulgings or domes vary in diameter from half a mile to four miles, and the outline is nearly circular or somewhat oval, though more or less irregular where they have encroached on one another.

1.



Map of the Henry Mountains.

The strata constituting them are those of the Cretaceous formation, which comprises, beginning above, the "Maruk," "Blue Gate" and "Tununk" sandstones, and "Henry's Park Group," and has there a thickness of 3,500 feet; the Jura-Trias, which is divided into the "Flaming Gorge," "Gray Cliff,"

* Report on the Geology of the Henry Mountains, by G. K. Gilbert. U. S. Geographical and Geological Survey of the Rocky Mountain Region, J. W. Powell in charge. 160 pp. 4to, with plates, maps, and sections. Department of the Interior. Washington, 1877. Although this date makes the printing of the Report to have been done in 1877, the volume has been issued within three months.

"Vermilion Cliff" and "Shinarump" groups, and has a thickness of 2,930 feet; and the Upper Carboniferous. These strata in the mountains are intersected by dikes of trachyte rising from a mass of trachyte below. The dip of the strata varies from zero at top and at base to various angles between, being even 80° in some of them just above the base; but the rocks beneath the plain around them are horizontal.

The quaquaversal dip in the strata appears to indicate, as Mr. Gilbert states, that the dome-like elevations were produced through force acting directly beneath each; and, from the position of the trachyte, the natural inference is drawn that the force was connected with the eruption of this igneous rock. In the ideal sections given, one of which is here reproduced, a mass of trachyte is represented occupying an oven-shaped cavity, with the strata bulged upward above while horizontal below. The trachytic mass is called a *laccolite*, from *λάκκος cistern*, and *λίθος stone.* (Since the termination *ite* is distinctive in science of names of *kinds* of minerals and rocks, the modified form of the term, *laccolith* (analogous to *monolith*) would be better, and is used below as essentially Mr. Gilbert's.)

2.

Ideal section of a Laccolith.

The laccoliths are flat, or nearly so, below, as was found to be true at eleven localities, showing that it had taken the form of the surface on which it rested. The thickness or height is sometimes over 3,000 feet; and the breadth is, on an average, seven times the height, but in one case only three times. The trachyte dikes which rise from it are much more numerous than might be inferred from the ideal section; and they often come up between the beds as well as intersect them. The sandstone above and below the trachytic mass, or adjoining the dikes, is usually more or less altered by the heat for a thickness of a foot or more. The erosion which has reduced the original domes to deeply gorged mountain peaks and ridges has in some of them exposed part of the interior laccolith so as to show its original surface, while in one the whole stands bare, but much eroded through the action of waters.

The chamber occupied by the laccolith was in all cases made along a shaly layer in the formation, where the cohesion was least. The trachyte is a compact porphyritic variety, wholly destitute of any trace of cellules. There are faint indications of three or four successive beds in some of the masses.

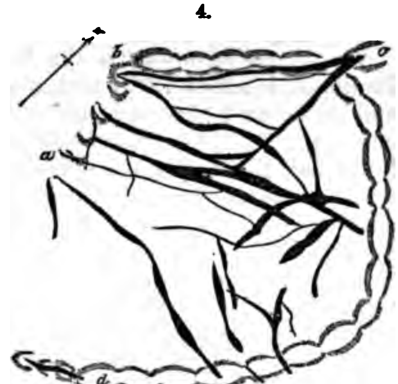
In further explanation of these peculiar mountain structures, the following sentences and illustrations are cited from Mr. Gilbert's Report.

In *Mt. Ellsworth* "from all sides the strata rise, slowly at first, but with steadily increasing rate, until the angle of 45° is reached. Then the dip as steadily diminishes to the center, where it is nothing. A model to exhibit the form of the dome would resemble a round-topped hat; only the level rim would join the side by a curve instead of an angle, and the sides would not be perpendicular, but would flare rapidly outward. (See fig. 3.) The base of the arch is not circular, but is slightly oval, the long diameter being one-third greater than the short. The length of the uplift is a little more than four miles; the width a little more than three miles, and the height about 5,000 feet. The curvature fades away so gradually at its outer limit that it is not easy to tell where it ends, and the horizontal dimensions assigned to the dome are no more than rude approximations." "Dikes and sheets abound from the crest of the dome down to what might be called its springing line—the line of maximum dip. At the center, dikes are more numerous; near the limit, sheets. The central area is crowded so full of dikes, and the weathering brings them so conspicuously to the surface, that the softer sedimentaries are half concealed, and from some points of view the trachyte appears to make the entire mass." The above diagram (figure 4) "shows the arrangement of the dikes in one of the outer amphitheaters of the mountain, where they are less complicated than in the central regions."

3.

Restoration of Mt. Ellsworth.

4.



Ground-plan of trachyte-dykes on the western flank of the mountain.

"The trachyte masses and the altered rocks in contact with them are so much more durable than the unaltered strata about them that they have been left by the erosion in protuberances. The outcrop of every dike and sheet is a crag or a ridge, and the mountain itself survives the general degradation of the country only in virtue of its firmer rock-masses. Nevertheless, the mountain, because it was higher than its surroundings, has been exposed to more rapid erosion, and has been deprived of a

greater depth of strata. From the base of the arch there have been worn 3,500 feet of Cretaceous, and from 500 to 1,500 feet of the Jura-Trias series, which is here about 3,000 feet thick. From the summit of the arch more than 2,500 feet of the Jura-Trias have been removed.

"The strata exposed high up on the mountain being older than those at the base, and the dip being everywhere directed away from the center, it is evident that the mountain is surrounded by concentric outcrops of beds which lift their escarpments toward it."

"The laccolite of Mount Ellsworth is not exposed to view, but I am nevertheless confident of its existence—that the visible arching strata envelop it, that the visible forest of dikes join it, and that the visible faulted blocks of the upper mountain achieved their displacement while floated by the still liquid lava. The proof, however, is not in the mountain itself, but depends on the association of the phenomena of curvature and dike and sheet with laccolites, in other mountains of the same group."

The Hillers laccolith "is the largest in the Henry Mountains. Its depth is about 7,000 feet, and its diameters are four miles and three and three-quarter miles. Its volume is about ten cubic miles. The upper half constitutes the mountain, the lower half the mountain's deep-laid foundation. Of the portion which is above ground, so to speak, and exposed to atmospheric degradation, less than one half has been stripped of its cover of arching strata. The remainder is still mantled and shielded by sedimentary beds and by many interleaved sheets of trachyte." "All about the eroded (south) face of the mountain the base is revetted by walls of Vermilion and Gray Cliff sandstone, strengthened by trachyte sheets. At the extreme south, these stand nearly vertical (80°), and their inclination diminishes gradually in each direction, until at the east and west bases of the mountain it is not more than 60°." "The same beds which form the revet-crags on the southern base constitute also some of the highest peaks. Since these rest directly upon the laccolite, it is assumed that the next lower beds of the stratigraphic series form its floor." "It is noteworthy that wherever the sedimentaries appear upon the mountain top they are highly metamorphic. But in the revet-crags [upturned Jura-Trias sandstone about the south side] there is very little alteration."

The *Mount Ellen Cluster* (map, p. 17), having a diameter from north to south of more than ten miles, contains, if rightly understood, no less than sixteen laccoliths "in the spurs and foot slopes and marginal buttes" about the central crest. A view of the western flank of the mountain is shown in figure 5. In this view, there are recognized, in front of the highest

portion, the remains of three laccoliths: to the left the "Geikie" laccolith; along the middle portion (S) the "Shoulder" laccolith, overlapping the base of the Geikie; and to the right (N) two miles to the south of the Geikie, is the "Newberry arch," the last making a knob 1700 feet high, standing by itself. In the rear is the pyramidal Ellen Peak; to the left of it, in the distance, is the "Marvine" laccolith; and, to the right, still

5.

Part of Mount Ellen from the west; highest point 11,250 feet.

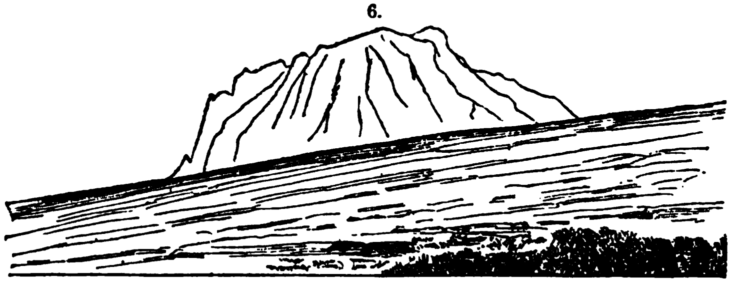
another, named the F laccolith. Lewis's Creek cuts across a flank of the Newberry arch and "exposes a portion of the [trachytic] nucleus," overlaid by 100 to 200 feet of shale, and this by the Henry's Fork conglomerate. Erosion has also exposed on two sides the interior trachyte of the Geikie laccolith. The high crest or central region of Mount Ellen is intersected by dikes of trachyte; moreover, Cretaceous shales are "baked to clinking slate," and sandstones are "greatly indurated," and there are beneath "perhaps the remains of laccolites."

The *Marvine laccolith*, one of the Mount Ellen group, "surrounded by nothing firmer than the Tununk shale and Tununk sandstone [Cretaceous], has suffered a rapid denudation, in which nearly the whole of its cover has been carried away without seriously impairing its form. It stands forth on a pedestal, devoid of talus, naked and alone. The upper surface undulates in low waves preserving the original form as it was impressed on the molten mass. Over a portion there is a thin coating of sandstone, the layer next to the trachyte being saved from destruction by the induration acquired during the hot contact. From the remainder this also has disappeared, and the contact face of the trachyte is bare." The extreme

depth of the laccolith is 1,200 feet, and its diameters are 6,000 and 4,000 feet.

In the *Jukes laccolith* "the trachyte has a depth of only one thousand feet, but it lies so high with reference to the general degradation that it is a conspicuous feature of the topography. The edges of the laccolite are all eaten away, and only the central portion survives. All of the faces are precipitous. The cover of shale or sandstone has completely disappeared, and the

6.



Jukes Butte, of the Ellen Cluster, as seen from the northwest.

upper surface seems uneven and worn; but a distant view (figure 6) shows that its wasting has not progressed so far as to destroy all trace of an original even surface. The eminences of the present surface combine to give to the eye which is aligned with their plane the impression of a straight line. The hill is loftier than the laccolite, for under the one thousand feet of trachyte are five hundred feet of softer rock which constitute its pedestal, and by their yielding undermine the laccolite and perpetuate its cliffs."

The laccoliths are described as occurring at different levels, between beds of the Carboniferous, Jura-Trias, and Cretaceous formations. The lowest in stratigraphical position, Mount Ellsworth, is 4,500 feet below the level of the highest; and it was probably covered originally by at least 7,000 feet of strata exclusive of the Tertiary. But since the Tertiary, according to Mr. Gilbert, probably spread over the region, and owes its absence only to subsequent denudation, the total thickness, since that of the Tertiary is 3,500 to 7,000 feet, may have been much over 10,000 feet.

The facts brought out appear to sustain Mr. Gilbert's conclusion that the mountains were made such, out of horizontal strata, by the ascending trachyte, which "insinuated itself between the strata, and opened for itself a chamber by lifting all the superior beds." (p. 19).

The steps in the early part of the history are given as follows on page 95 of the Report.

"When lavas, forced upward from lower-lying reservoirs, reach the zone in which there is the least hydrostatic resistance to their accumulation, they cease to rise. If this zone is at the top of the earth's crust they build volcanoes; if it is beneath, they build laccolites. Light lavas are more apt to produce volcanoes; heavy, laccolites. The porphyritic trachytes of the Plateau Province produced laccolites."

"The station of the laccolite being decided, the first step in its formation is the intrusion along a parting of strata, of a thin sheet of lava, which spreads until it has an area adequate, on the principle of the hydrostatic press, to the deformation of the covering strata. The spreading sheet always extends itself in the direction of least resistance, and if the resistances are equal on all sides, takes a circular form. So soon as the lava can uparch the strata it does so, and the sheet becomes a laccolite. With the continued addition of lava the laccolite grows in height and width, until finally the supply of material or the propelling force so far diminishes that the lava clogs by congelation in its conduit and the inflow stops." "A second irruption may take place either before or after the first is solidified. It may intrude above or it may intrude beneath it; and observation has not yet distinguished the one from the other. In any case it carries forward the deformation of cover that was begun by the first, and combines with it in such way that the compound form is symmetric, and is substantially the same that would have been produced if the two irruptions were combined in one. Thus the laccolite grows by successive accretions until at length its cooled mass, heavier and stronger than the surrounding rocks, proves a sufficient obstacle to intrusion."

The lifting force was thus due to the forced upward-flow of the lava: and it became able to overcome the resistance from the weight and cohesion of the rocks above by spreading into an opening between the horizontal strata, and widening the area of pressure.

The force communicated to the lavas at their source below was hence sufficient, it would appear, to throw a stream, in spite of friction along the passage and the density of the material (at least 2·33 in fusion), for an unknown number of miles, up to the laccolith level; and sufficient at this point, further, to lift, in the case of the lowest of the laccoliths, a superincumbent mass of beds 10,000 feet thick (supposing the Tertiary at top 3,000 feet of it) and 2·25 in average specific gravity (equivalent in pressure to 675 atmospheres) to a height of 5,000 feet.

The Report offers no views as to the origin of the propelling force. Whatever the source, it is possible that some accession of energy may have come from vapors derived by the ascending lavas from subterranean moisture or waters encountered on their way up, though slight compared with the vast amount received from action below.

The idea in the commencement of the above citation—that hydrostatic pressure determined the level of the laccolith among the strata—is dwelt upon at length in the preceding pages of the Report. The author argues that the relation as to density between the liquid trachyte and the several associated stratified rocks, and between the latter among themselves (the several densities of which he gives), is the chief cause determining the level among the strata of the laccoliths; saying that the lava, free to move upward or laterally, will intrude itself among the strata at a point "so placed that every combination of superior beds, which includes the lowest, shall have a less average density, and every combination of inferior strata, which includes the highest, shall have a greater density, than that of the lava." "If the fluid rock is less dense than the solid, it will pass through it to the surface, and build a subaerial mountain," or "volcano;" if more dense than the upper portion of the solid rock, the fluid will not rise to the surface, but will pass between the heavy and light solids, and lift or float the latter." Cohesion in the rocks modifies the result; but, he says, nevertheless, after discussing this point, "we are led to conclude that the conditions which determined the results of igneous activity were the relative densities of the intruding lavas and of the invaded strata; and that the fulfillment of the general law of hydrostatics was not materially modified by the rigidity and cohesion of the strata."

We refer to the report for a full explanation of this part of Mr. Gilbert's theory. To the writer, his explanation appears to be complete, without reference to this difference of density. With so powerful a forced movement in the lavas as the facts, if they are rightly interpreted, show to have existed, no other cause could be needed for a flow to the surface in case of an open channel, or for a flow to any level in the strata at which a fissure might terminate; and this is true, whether the lava be light or heavy. In fact *heavy* lavas, having a specific gravity of 2·85 to 3·1, make the larger part of modern volcanic cones, as well as of non-volcanic igneous outflows, and one of the lighter lavas—trachyte, of the specific gravity 2·61, by Mr. Gilbert's determination—made the laccoliths.

These lighter lavas are adapted to the purpose because they are the least fusible of ordinary igneous rocks; and they owe their difficult fusibility to the orthoclase feldspar which is the chief constituent, whose fusibility on Von Kobell's scale is marked 5, while that of albite is marked 4, and of labradorite and volcanic augite, 3. Such lavas are hence easily chilled and thicken greatly in the upper part of narrow fissures or of volcanic conduits, and it is for this reason that they have often made steep-sided *domes* over subaerial vents.

If the first step in the history of the laccoliths was the making of intersecting fissures narrowing upward, some reaching to the surface, it may be, and others to different levels in the strata, the trachytic lava passing up would tend to become thickened by cooling, or might even become solidified, in the upper part of such fissures, because of the large extent of the cooling surfaces as compared with the amount of liquid. But along their intersections it would be most sure to remain liquid, and here conduits would become localized, from which the upward forced liquid rock might spread laterally, whatever the height, and produce the laccolith. The ready cooling of the trachyte would tend to limit the lateral flow of the lavas in such chambers, and so aid in producing the thick form of the laccolith, besides preventing a waste of energy. With intermissions in the flow, the trachyte of the chamber would be intermittent in its enlargement, and receive that degree of bedded structure which, according to Mr. Gilbert, exists.

The facts give some hints as to the source of the great force producing the upflow of lavas in non-volcanic fissure-ejections. They make the vast extent of such outflows, as those over California, Oregon, India and other regions, intelligible. Volcanoes are small outlets compared with fissures that extend for miles, and the forces they command are feeble compared with the action which makes such fissures. The opening of one or more great fissures is the initial step in the making of a volcano; and the volcano is the open chimney or vent left after the fissure-action had spent its force—a point illustrated by the writer in his account of the Hawaiian islands and their volcanic origin.* J. D. DANA.

ART. IV.—*Some Thoughts on the Glycogenic Function of the Liver.* II. *Disposal of Waste;* by JOSEPH LECONTE.

[Read to the National Academy of Sciences, October 30, 1879.]

IN my previous paper,† I attempted to show that the well known and remarkable fact that nearly the whole food absorbed from the alimentary canal is distributed through the liver before it reaches the general circulation, is proof that, in a very important way, the liver prepares the food for the uses to which it is applied in the animal body: and further that the preparation is accomplished by the glycogenic function. According to my view there are three sources of glycogen, viz: 1. The whole of the amyloids: these are arrested in the liver as glyco-

* Expl. Exp. Rep. Geology, 1849. † This Journal, xv, 99.

gen and re-delivered as liver-sugar, little by little as required, and burned. 2. *Albuminoid excess:* this is split into a combustible portion (glycogen) which is delivered to the blood as liver-sugar and burned, and an incombustible portion which is either urea or rapidly sinks into urea and is eliminated by the kidneys. 3. *Waste tissue:* this is also split in the liver and disposed of like the last. There are the same three sources of vital force and animal heat, viz: 1. the combustion of the whole of the amyloids; 2. the combustion of the combustible portion of albuminoid food excess; and 3, the combustion of the combustible portion of waste tissues. Therefore the function of the liver is to prepare *all* the fuel of the body, and this fuel is only liver-sugar.

Now it has been brought to my attention that my account of the disposal of waste is in conflict with the usual view of physiologists, which view is supported by many facts. Let us then state sharply the difference.

According to the usual view, oxygen taken in at the lungs is carried by the arterial blood to the tissues, there seizes with avidity upon these at the moment of their decomposition, changes them into CO_2, H_2O and urea; and then these final products of combustion only are carried by the venous blood to be eliminated by lungs and kidneys. According to my view on the contrary, waste tissue is not burned or changed into final products at once, but circulates as incombustible matter dissolved in the blood, is carried to the liver, and there prepared for final combustion and elimination, and only thereafter does it unite with oxygen to form CO_2 and H_2O. We see the contrast; which view is right?

There are some facts which strongly support each view. The usual view that waste tissue is burned at once and only the final products of combustion circulate in the blood, is supposed to be sustained: 1. by the fact that the change from bright to dark blood, the exchange of oxygen for carbonic acid, and therefore the combustion, takes place principally if not entirely in the capillaries and therefore in contact with the tissues; and 2, by the additional fact, that increased activity of any organ, e. g., a muscle, is attended with increased heat, increased waste, and therefore presumably of increased *combustion of waste.* But, on the other hand, my view is sustained by the experiments of Schiff, already alluded to in my previous paper. These experiments prove in the most positive manner, that poisonous waste is carried to the liver and there decomposed and made comparatively innocuous.

Here then are two incontestible facts: 1. The combustion of waste takes place principally, if not wholly in the capillaries and therefore in contact with the tissues. 2. The waste is not

burned as such, as soon as formed, but must be carried to the liver to be prepared for final combustion. These two facts must be brought together and reconciled. I think this may be done as follows:

First, it must be remembered that *waste* is but a *small fraction* of the material used as fuel, by far the larger portion of such material being *food* which never becomes tissue at all, viz: *amyloids* and *albuminoid excess.* Now these also, although they, or the fuel made from them, are confessedly carried and burned in the blood, are burned principally in the capillaries and therefore in contact with the tissues. The reasons then, for burning combustible *food* principally in the capillaries, would equally apply to burning combustible *waste* in the same place, and therefore the fact that combustible waste is burned principally in the capillaries is no argument that it is burned as soon as formed. Evidently then the question is not one which concerns the combustion of *waste* alone, but the combustion of *all* fuel. The question is, why does combustion of the combustible portion both of food and waste, take place, and therefore both heat and other forms of force are generated, in the capillaries and in contact with the tissues? The *final* cause is, indeed, plain enough; it takes place there, because *there* the force is wanted; but what is the *physical* cause, or the process which determines this result? There are probably several.

1. The blood is much *longer time* in the capillaries than in any other portion of its course, and therefore even if the *rate* of combustion be *uniform*, the amount of combustion would be greater there than in any other place; and moreover, if increased activity, increases heat and therefore combustion, it does so because it also increases the blood-supply.

2. But probably the rate of combustion in the course of circulation is *not uniform.* It is probable that the tissues themselves are an apparatus for causing or accelerating combustion. The termination of nerve-fibers in the tissues, and the controlling influence of nerves over all functions, suggests that the discharge or the arrest of nerve-current, in some way which we do not yet understand, is the principal cause of combustion and therefore of generation of force there. Farther: it has been suggested to me by Mr. Christy, an assistant in the chemical laboratory, that the chemical process may possibly be something like this: oxygen is carried by the hæmoglobin, the fuel is carried as liver-sugar by the plasma, side by side in the same current; nerve discharge reverses the order of affinity and the oxygen immediately leaves the hæmoglobin to seize the sugar. In most tissues, such as many glands, etc., which are constantly active; and in all tissues so far as the function of nutrition is concerned, the process is continuous and under the influence of

the sympathetic or vaso-moter system. In muscular contraction, on the other hand, the discharge is powerful and periodic, and under the influence of the voluntary or of the reflex system.

3. It is probable also, nay almost certain, that the first decomposition of tissue, short of combustion, i. e. the first formation of waste, being a descensive change, a change from a less stable to a more stable condition, is itself a process by which heat and other forms of force are generated. This of course takes place only in the tissues.

My view, therefore, is briefly as follows: The liver-sugar formed from the sources already mentioned, 1st, commences to burn in the capillaries of the lungs, and 2nd, continues to burn in the course of the arterial circulation. The combustion thus far produces only *heat.* But 3rd, the main combustion takes place in the capillaries, probably under the influence of nerve-discharge, and this part generates not only heat but *other forms of force* characteristic of the peculiar tissue. But the fact that the main combustion takes place in contact with the tissues, has misled physiologists to believe that the tissues themselves are burned.

It seems to me that physiologists do not even yet sufficiently appreciate the function of the blood as a reservoir. The blood must be regarded as a reservoir not only for oxygen and carbonic acid, but also and still more for *food*, for *fuel* and for *waste.* It is now well recognized as a reservoir for oxygen and carbonic acid, but not sufficiently for food and waste. The tissue-food of to-day, is not used for building to-day; but the blood is drafted upon for materials for this purpose and re-supplies itself from albuminoid food. The amyloid food of to-day, is not burned to-day; but the blood is drafted upon for fuel and re-supplies itself from the liver, while the liver in its turn, re supplies itself from the amyloid food.* So also waste tissue of to-day is not mainly burned and eliminated to-day; but the blood is again drafted upon for fuel from this source and re-supplies itself from the liver and the liver from the tissues.

Finally, it will be observed that the view which I here present, as to the disposal of waste, is in some respects intermediate between the view of the old physiologists under the guidance of Lavoisier, and the usual modern view. According to the old view, waste is dissolved in the blood, carried to the eliminating organs especially the lungs, and *there* burned with rejection of the products of combustion. The lungs is there-

* The rapidity with which the fuel-supply in the blood is exhausted by activity and restored by food, is far greater in some insects, e. g., bees, than in higher animals. In bees, one hour of activity without food entirely exhausts, while food restores in five minutes. This is the result of the extraordinary nervous and muscular activity of these insects.

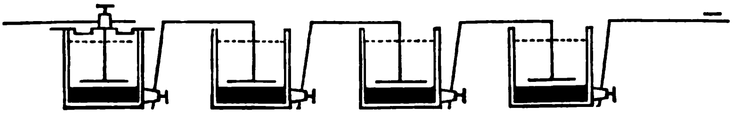
ɔ the furnace of the body. According to the usual modern w, oxygen is taken into the blood, is carried to the tissues, ·ns there on the spot the waste, and the products of combus· n are then carried to be eliminated in the lungs. The old w is right in supposing that waste is carried in the blood, t wrong in supposing it to be combustible and therefore rned as soon as it meets oxygen in the lungs. The modern w is right in supposing that combustion takes place mainly the tissues and not in the lungs, but wrong in supposing it it is the unprepared waste which is there burned.

ɪᴛ. V.—*On Electrolytic Phenomena;* by Wallace Goold Levison.

stract of a paper read before the New York Academy of Sciences, February 10, 1879.

In 1866 I devised a battery in which the usual plate of zinc other electro-positive metal is replaced by a surface of liquid lium or potassium amalgam. It differs from any such bat- y to my knowledge previously constructed, in that the amal- m is perfectly fluid and its surface visible. It may be made two forms.

1.



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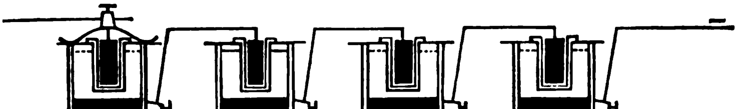


e first consists of a glass cup containing two or three centi- ters in depth of 10 per cent sodium amalgam and filled with ter. In this water a flat coil of platinized lead wire is sus- nded over the amalgam, and through a perforation in the e of the cup near the bottom a screw cup connects with ɔ amalgam. A wire from this screw cup forms the negative le, a wire from the lead coil the positive pole. This battery strongly alkaline, yet gives quite a strong current. The :ond form is varied by substituting for the lead coil a porous p containing nitric acid and a slip of platinum, and for the ter, dilute sulphuric acid. This form of battery gives a ry strong current. When several cells of the latter form are mbined, on making or breaking circuit, a motion of the

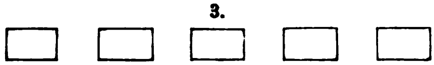
amalgam is observed, which seems to arise from its being raised in the center while the current flows and its falling to the normal level when it is interrupted.

While the circuit is broken there is a constant evolution of hydrogen gas in very fine bubbles from the entire surface of the amalgam. When the circuit is closed they no longer escape freely at the point of evolution, but glide over its surface from all sides toward the center where they coalesce to form large bubbles, which there escape. These bubbles are abnormally spread or flattened out upon the surface of the amalgam, escape with a peculiar trembling as if with difficulty, and if caught under the porous cup they still exhibit the flattened aspect. On breaking the current they become hemispherical and again escape readily from all parts of the liquid surface. Some of the phenomena thus observed I have since contrived to exhibit in another form by means of the vertical lantern, using an ordinary horizontal cell five inches in diameter, which, however, is especially prepared for the purpose by cutting a groove in the glass across it just deep enough to keep a long globule of mercury in place, and slightly shallower in the middle, so as to hold two globules of mercury opposite each other. When a globule of mercury three centimeters long is held in one end of the groove touched by the negative pole of a four-cup Bunsen battery, the cell filled with dilute sulphuric acid, the positive pole touched to the electrolyte at the opposite end of the groove, and by means of an included signal key, the current sent through the circuit, the globule of mercury instantly extends. On breaking the circuit it resumes its normal form. On reversing the direction of the current by a pole changer, again closing circuit by the key, and allowing the current to pass continuously, the globule is at first agitated and repelled by the positive pole, but after a moment is again attracted. A globule at the opposite pole acts in a similar manner. Two globules at opposite poles first attract each other, on reversing current both are repelled for a moment and then being again attracted, extend toward each other. The exact amount of this attraction and repulsion may be measured by means of a perpendicular U tube containing mercury and dilute sulphuric acid over the mercury in one branch, the battery terminals being immersed in the electrolyte on one side and mercury on the other. When the current flows, the mercury column being the negative pole, it will rise toward the positive wire. On reversing the current it will be more or less repelled below normal level. A capillary tube is not necessary as it may be a centimeter in internal diameter. In all cases of attraction the globule or column seems to be constricted near the end as if it tended to part at that point and the negative

globule frequently does part throwing off a small globule which runs to the anode; in all cases of repulsion the end tends to spread or enlarge.

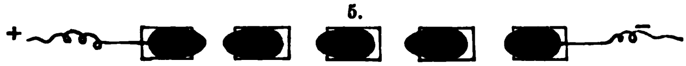
Fusible metal in hot solution of sodic sulphate, or dilute sulphuric acid in a glass tube, and metallic lead under fused chloride of sodium, in a grooved scorifier, in a muffle at a red heat, exhibit the same phenomena; hence they are not peculiar to mercury or amalgams. If, instead of a long groove as described, a series of five short grooves be cut (as shown in fig. 3) so as to hold five globules of mercury in a line and the end globules be touched by the terminal wires (as shown in fig. 4), on making connection they become almond-shaped (as shown in fig. 5). The positive globule extends toward the negative pole, the other four all extend toward the positive pole.

3.



4.

5.



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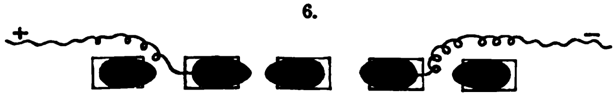

If the terminal wires be touched to the second and fourth globules, the second being positive, extends toward the negative pole, the middle and fourth extend toward the positive pole, and the end globules though not included in the circuit extend toward the center. (See fig. 6.) These are fine experiments to project before an audience, and they may be greatly varied.

In both these cell experiments small globules that lie on the plane surface of the glass move either against the rim of the cell, or in smaller semi-circles concentric with it from the positive to the negative pole, or toward the end at which hydrogen bubbles are escaping. The curves in which these globules move, may be conveniently regarded as *lines of voltaic force*, and the space between and surrounding the electrodes as the *voltaic field.* If the mercury used in these experiments contain the least trace of zinc or other metal, the phenomena will be considerably modified.

When sodium amalgam is substituted for pure mercury as the negative globule in the single globule experiment, it is always at first repelled as though it had previously been the negative terminal, and then the poles had been reversed.

When pure mercury is thus employed as the negative globule under sodic sulphate, it becomes sodium amalgam, and the violent agitation which accompanies the repulsion of the globule on reversing the current is probably due to the rapid oxidation of the occluded sodium.

When, however, sulphuric acid is used as the electrolyte, the globule could only occlude hydrogen. Since in the latter case it acts in a somewhat similar manner, it is possible that hydrogen is thus occluded, and from its rapid oxidation arises the agitation of the globule on reversing the current. The question might perhaps be decided by the Sprengel pump.

Two platinum electrodes delicately suspended near together in dilute hydric sulphate, will repeatedly attract each other, and at the moment of contact fall apart again, each separation being accompanied by a bright spark. Two plates of carbon delicately suspended are perceptibly attracted when they form the electrodes in dilute hydric sulphate or other electrolyte of a 20-cell Bunsen battery.

The attraction of solid electrodes may be due merely to the escape from them of gas bubbles, but the motion seems to be simultaneous with the closing of the circuit and to precede momentarily the evolution of the gas.

The currents in the electrolyte, to which most previous observers have attributed the movements of the globules of mercury, may be beautifully shown by projection on a screen if a number of globules between the poles are held in depressions in the rubber bottom of an ordinary upright clamp cell.

I have given a great deal of consideration to the phenomena described in this paper and to the views of those who have studied them, and though I am not able to give expression to the law by which they are governed, I can not accept any suggestion as yet advanced. I believe, however, that they offer the way to an important discovery, perhaps the mode of transmission of the electric current, when the methods of exhibiting them herein described, the abnormal behavior of gas bubbles in the sodium amalgam battery, the movements of metals and alloys other than mercury itself, the transmission of globules across the voltaic field, the mode of measuring the attraction and repulsion unimpeded by capillary force, and the movements of solid electrodes, attract the attention of observers provided with recent facilities for experimentally examining them, and that the results may lead to the complete development of a series of phenomena that have long awaited investigation.

ART. VI.—*Notice of New Forms of Fossil Crustaceans from the Upper Devonian Rocks of Ohio, with descriptions of New Genera and Species*; by R. P. WHITFIELD.*

IN the 16th Report of the State Cabinet of New York, there is described and figured a peculiar bivalve crustacean from the Hamilton formation of New York, under the name *Ceratiocaris punctatus*. It is again repeated on Plate 23, fig. 7, of the Illustrations of Devonian Fossils, Section Crustacea, under the name *Ceratiocaris* (*Aristozoe*) *punctatus*. Among the fossils of the Ohio Geological Survey, there are represented three species of similar form, but specifically distinct from the above; and I have seen examples of at least two species from the Hamilton and Chemung groups of New York, which may be distinct from any of these.

These fossils differ from the true type of *Ceratiocaris* in so many particulars, and to so great an extent, that it is quite impossible to include them in that genus. The reference to *Aristozoe* Barrande, is, however, still more erroneous, as the forms to which that name is applied are true *Ostracoides*, having all their parts concealed within the carapace, as in the *Leperditia* and its allies; while the forms under consideration are provided with a bivalve or, at least, a two-sided carapace, which incloses the thoracic portions; while the abdomen and caudal parts are naked, or not inclosed within this covering; and are more properly classed among the *Phyllopods*.

That this latter character, the naked abdomen and caudal plate, pertains to these organisms, is abundantly proven by the Ohio specimens now under consideration. The fossils are found inclosed in small concretions; and there would be but little chance for specimens, or parts of specimens of different species, or, less likely, of parts of individuals of distantly related generic forms, to be inclosed in the same small concretion; so we may safely conclude, that, where parts or fragments of individuals of corresponding size are found in the same concretion, they are parts of one individual or, at least, of the same species. In the concretions in question there are two examples where parts of the naked abdomen and caudal plate with its accompanying spines, are imbedded in the concretion together with the carapace which I have classed as the same species. This I consider as ample proof that the parts belong to the one individual; and that the animal of which they are the remains, was provided with a naked body and spinose caudal appendage as in *Ceratiocaris*. It is also

* These descriptions will be repeated in vol. iii, Paleont. Ohio, with illustrations of the species. All the specimens are from the cabinet of Dr. J. S. Newberry.

stated in the Illustrations of Devonian Fossils that one specimen resembling *C. punctatus* has been found with a body similar to that called *C. armatus* attached to the carapace, showing their individual relations.

The several species above mentioned, while differing greatly from *Ceratiocaris*, possess features in common which at once characterizes them as a natural group, sufficiently marked to be readily distinguished. I therefore propose to recognize them as a distinct genus under the generic name ECHINOCARIS, possessing the following characters:

ECHINOCARIS, new genus.

Carapace bivalve, valves subovate in outline; united on the dorsal margin by a straight hinge; the anterior, basal and posterior margins rounded, and generally more or less produced posteriorly. Surface of the valves marked by a more or less distinctly elevated, curved, longitudinal ridge, centrally or subcentrally situated; also by one or more (usually three) vertical ridges, or ridge-like nodes, extending downward from the hinge-line upon the body of the valve, and usually situated anterior to the middle of the length. Abdomen naked, composed of several segments (four known) and a caudal plate, which is produced into an elongated spine with a lateral, movable spine on each side. Posterior margin of the abdominal segments bearing spines on the now known species. Type *Echinocaris sublevis* Whitf.

Among the genera now known and referred to the *Ceratiocaridæ*, there are several distinct types of structure, indicated by the features of the carapace alone, independent of the changes which take place in the abdominal segments and in the caudal spine and appendages. The following synopsis of some of their characters may serve to illustrate their peculiarities and to show more distinctly the relations which *Echinocaris* bears to other known genera.

1st section: Carapace more or less elongated, with a straight or slightly arched dorsal line; anterior end sharply rounded or pointed (rostrate); posterior end truncate; sides convex, smooth or simply striate, sometimes marked by a simple ocular node near the antero-dorsal margin; no ridges or other nodes. *Ceratiocaris* McCoy, 1849; *Caryocaris* Salter, 1862; *Hymenocaris* Salter, 1852; *Solenocaris* Meek, 1872; (?) *Colpocaris* Meek, 1872. The last somewhat questionable in character.

2d section: Carapace similar in form to that of section 1, with the postero-basal angles produced into spines, and the surface with longitudinal ridges. *Dithyrocaris* Scouler (=*Argas* Scouler).

3d section: Carapace rounded at both extremities, elongate-

elliptical or elongate-ovate in form, with a straight dorsal margin; surface concentrically striate, no nodes or ridges. *Lingulocaris* Salter, 1866.

4th section: Carapace triangular, dorsal margin straight; surface punctate or reticulate, and concentrically striated (growth lines?). *Dictyocaris* Salter, 1860.

5th section: Carapace suboval or subovate, with a straight hinge-line: surface marked with longitudinal ridges or representative nodes and ridges; surface of parts smooth, punctate or pustulose. *Echinocaris*, new gen.

6th section: Carapace broadly oval or ovate; no straight cardinal line, consequently no hinge; anterior end rostrated or beaked; surface destitute of nodes or ridges. *Physocaris* Salter, 1860.

7th section: Carapace composed of three pieces, or apparently of three, two of which are semi-circular, with the anterior end of each obliquely truncate, forming, when the two are united, an anterior triangular notch into which the third or rostral plate is inserted; surface concentrically marked by growth lines; no nodes or ridges. *Peltocaris* Salter, 1866; *Discinocaris* Woodward, 1866; *Aptichopsis* Barrande, 1872; *Pterocaris* Barrande, 1872 (not Heller, 1862).

It will be readily seen, from the above synopsis, that *Echinocaris* differs materially in the features of the carapace from all the other genera enumerated. The features of the abdomen and caudal parts are not as reliable as those of the carapace, but are somewhat distinctive, as may be seen by the following table of comparison. (A mark of interrogation indicates that the parts are unknown or only partially known.)

Genus.	Abdominal segments.	Caudal spines.
Ceratiocaris	5 or 6 smooth	3
Dithyrocaris	1 smooth	3
Hymenocaris	8 smooth	6
Dictyocaris	6 smooth	3 ?
Physocaris	5 smooth	3
Echinocaris	4 spiney	3
Discinocaris	4 ?	3 ?
Peltocaris	3 smooth	3
Caryocaris	1 ?	3
Lingulocaris	?	?
Colpocaris	?	3
Solenocaris	?	?
Aptychopsis	?	?

The number of segments here allotted to any given genus indicates the maximum number of naked segments known: some of them contain species having a smaller number, and in some a much greater number exists, some of which are concealed within the carapace. Thus *Ceratiocaris* is known to possess in one species fourteen segments in the abdomen, only six of which are naked.

The genus *Dithyrocaris* McCoy is described as having three longitudinal ridges on the carapace. This feature is seen only when the two valves are pressed open as in McCoy's example, so as to present the appearance of one large plate; in which case the hinge-line forms the middle ridge.

The third or rostral plate in *Peltocaris*, *Caryocaris*, *Discinocaris* and *Aptychopsis*, would appear to be quite analogous to the small rostral plate seen in *Ceratiocaris*, and supposed to exist in *Dithyrocaris*, and perhaps some others, but which is usually absent. It is possible many of the forms may have possessed this rostral plate, at least among those that are deeply notched in front when the valves are spread open. In this case they would as properly be considered as having three plates in the carapace as those grouped under section 7. The forms of this section are usually found with the carapace spread open on the rock, and are then circular and discoid, but when in their natural position would have been more or less roof-shaped.

Colpocaris Meek presents some features which raise a question as to its true affinities. The longitudinal crenulated line and the inflection of the supposed ventral border do not seem to be properly understood; and I am of the opinion it may belong to a different group of Crustaceans.

ECHINOCARIS SUBLEVIS, n. sp.

Carapace obliquely subovate in general outline, the height equal to two-thirds the length, widest and deepest behind the middle, the posterior portion projecting obliquely backward and downward beyond the extremity of the hinge-line; dorsal-line straight, forming a hinge-line two-thirds the length of the valve; outer margin of the valves, except on the dorsum, bordered by a narrow, slightly raised and thickened rim; anterior border nearly vertical from the extremity of the dorsal line, for about one-half the width of the valve, except a very slight rounding backward to the hinge-line above; below it slopes abruptly backward to and along the basal line, and again more abruptly curving around the posterior end of the valve and forward to the extremity of the cardinal line; below which it is distinctly excavated. The portion of the valve which projects beyond the hinge is nearly or quite equal to one-third the length of the valve. Surface of the valves convex, and marked by ridges and tubercles. The principal ridge commences at about the anterior third of the valve, and just above the middle, as an elevated, rounded and nearly vertical ridge; but soon bends somewhat abruptly, and is directed backward in a broad, sweeping curve, at less than one-third of the height of the valve from the lower margin, and gradually decreasing in strength ter-

minates a little within the margin opposite the longest part of the valve. A second and slightly stronger ridge rises from just behind the middle of the length of the hinge, descends with a gentle forward curvature, and terminates near the upper anterior end of the first one. The anterior or principal tubercle is large and distinct, and situated near the antero-dorsal angle of the valve, occupying the greater part of the space between the front margin and the two ridges just described. Between this and the second ridge, the surface is elevated, forming a low tubercle. The surface of the anterior tubercle is occupied by several small but distinct pustules, and the entire surface of the valve is covered by a minutely granulose structure.

Abdomen apparently consisting of four free segments; the first one being short and much thicker than the others on the anterior end, but rapidly narrowed posteriorly; the posterior margin being armed with several small spine-like tubercles. The other three segments are shorter than wide, gradually decreasing in strength and increasing in length backward, the first of the three being apparently less than half as long as wide, their posterior margins all spine-bearing; a long, curved spine on each side, with three short ones between, and all increasing in length backward from the first or anterior segment.

Telson proportionally large, of a general triangular form, but slightly protruding at the origin of the movable spines, and projected behind into a long, slender, and apparently cylindrical spine, making the telson with its spine about as long as the four free segments together. Lateral spines cylindrical, very gently curved, and standing at an angle of about forty-five degrees to the central spine. Surface of the telson highly convex and somewhat angular at the origin of the spine. Surface of the crust of the abdomen smooth.

This species is closely allied in the form of the carapace to *E. punctatus* (*Ceratiocaris punctatus* Hall, 16th Rept. State Cab. N. Y., p. 74, plate 8, fig. 1), but differs in the form of the nodes and ridges, and in the surface structure; also in wanting the projection at the posterior end of the hinge, if this feature is natural on that specimen. It is probable that the abdomen and telson figured on the same plate under the name *Ceratiocaris armatus* belongs to the same species as the carapace of *E. punctatus*, as suggested by Professor Hall in the explanation of plate 23, section Crustacea, Illust. Devon. Fossils; and if so, the distinction between these two parts of the two species is much more marked than between the carapaces.

Formation and locality.—In small calcareous concretions in the Erie shales (Portage and Chemung), at Leroy, Lake County, Ohio.

ECHINOCARIS PUSTULOSA, n. sp.

Carapace ovate, widest anterior to the middle, the greatest height equal to three-fourths of the length; hinge-line straight, rather more than half as long as the valve, while nearly one-third the length of the valve projects behind its extremity; margin of the valve bordered by a narrow, thickened rim; anterior end of the valve slightly excavated below the hinge extremity, and the margin broadly rounded in front; posterior end more pointed, while the basal line is broadly and evenly curved. At the posterior end of the hinge the margin is also slightly constricted as in front. Surface of the valve convex and marked by the characteristic nodes or ridges. The principal ridge commences in an oval node, which is situated just within the anterior third of the length of the valve; is placed vertically, just above the middle of the height, and the horizontal portion, which is sharply elevated and slightly curved, is situated almost in the middle of the width, and terminates a little less than one-fourth of the length from the posterior extremity. The second ridge commences at the hinge-line near the middle of its length, and descends with a slightly forward direction to within a very short distance of the top of the vertical portion of the principal ridge. The anterior ridge, corresponding to the anterior node or tubercle of *E. sublevis*, is narrow and nearly vertical; of a slightly sigmoid form, and originates near the anterior extremity of the hinge-line; the lower end reaching more than one-third the depth of the valve. The surface of the ridges and of the valve in the postero-dorsal field, as also of the space below the principal horizontal ridge, is marked by correspondingly large and distinct postules. Abdomen and telson unknown.

This species differs from *E. sublevis* in its slightly broader form, and in the want of the obliquity of the axis of the valve with the hinge; in the narrower posterior extremity, pustulose surface, and in the form of the surface ridges; most notably in the anterior one being ridge-like and vertically sigmoid instead of round. The individual used in description is half an inch in length and three-eighths of an inch in its greatest height.

Formation and locality.—In calcareous concretions in the Erie shales, at Leroy, Lake County, Ohio.

ECHINOCARIS MULTINODOSA, n. sp.

Carapace elongate-subovate, about twice as long as high, rounded in front and somewhat pointed behind; the basal line straightened along the middle portion and parallel to the hinge-line; cardinal line straight and nearly half as long as the length of the valve, and a little nearer the anterior than to the posterior end of the carapace. Margin of the valves

bordered by a narrow, elevated, thickened rim, which is expanded considerably in width around the anterior end of the valve, and terminates in a rounded, elongated ridge at the posterior extremity of the hinge; from which point the ridge is directed obliquely forward and slightly downward from the cardinal line. The surface of each valve is divided into three slightly elevated areas, with depressed sulci between; an anterior, a central and a posterior one. The first is situated in the middle of the anterior end of the shell; the central one unites with the anterior one below, and extends along the basal margin behind, in a narrow curved point below the posterior one, and projects upward near the center of the valve in a triangular form, terminating in an elevated point just above the median line; the posterior and largest area is ovate in form, and occupies a little less than one-half the length of the shell, is narrowed in front and pointed behind, taking the form of the extremity of the shell. The center of the anterior area is slightly tumid. Along the hinge-line and just below its margin there are three subangular tubercles or nodes, at nearly equal distances and of nearly equal strength, except that the posterior one is prolonged at its base into a low, rounded and slightly curved elevation, which extends to near the point of the central raised area before mentioned. These three nodes, together with the oblique, ridge-like one terminating the marginal rim, border the hinge-line on each valve. General surface of the valve finely punctate, but most distinctly so on the posterior field.

The elongated form of the carapace readily distinguishes this from any of the other species described, while the number of node-like ridges is a very marked feature. The abdomen and telson of this species have not been observed, although several imperfect carapaces, mostly showing parts of both valves, have been obtained.

Formation and locality.—In calcareous concretions in the Erie shales, at Leroy, Lake County, Ohio.

Associated with the Entomostraca, above described as from the concretions of the Erie shales of Ohio, are the remains of a *Macrouran Decapod*, which appears to differ so much from any described genus as to make it undesirable to refer it to any of them. One of its peculiarities consists in the possession of a pair of very strong antennal appendages which project from beneath the anterior end of the thoracic carapace, of such size and strength as to raise considerable doubt as to their true nature. The existence of five thoracic limbs, exclusive of these, projecting from beneath the carapace on one side would seem to place their pedal nature out of the question; while their great development as seen on the specimen would indicate that they had served some purpose other than simple antennæ, and to raise the

question as to the possibility of their having been chelate at their extremities. As only the basal portions of these organs are represented, however, this question cannot be satisfactorily determined. Having had an opportunity of consulting Dr. A. S. Packard, Jr., in regard to them, he gave as his opinion, that from their position and the representation of the other five pairs of thoracic members without them, they could not be other than antennal in their functions, notwithstanding their great size and anomalous character. Taking this view of their nature, the specimen would conform strictly to the type of Macrouran Decapods.

In its generic relations, as well as in its general expression, the specimen resembles most nearly the genus *Pygocephalus* of Professor Huxley, first given in the Quart. Jour. Geol. Soc. London, vol. xiii, p. 363, 1857, with figures and descriptions of three specimens, under the name *P. Cooperi.* Neither the genus nor species were well characterized at that time. It is, however, again referred to in vol. xviii, p. 420, of the same Journal, and a figure given of a specimen supposed to be of the same species, much better preserved, from the Coal shales at Paisley. There are, however, too many limbs represented as originating from the thorax for a Decapod; and the antennæ, although represented as of large size, are not like those of the Ohio specimen, while there is a second pair shown. In other parts the figure is indistinct, and in the description the parts are not defined sufficiently for close comparison. The differences, however, are so great that I shall propose for this form the new generic name PALÆOPALÆMON, with the following diagnosis.

PALÆOPALÆMON, new genus.

A Macrouran Decapod crustacean, having a shrimp-like body, with a thoracic carapace narrowed but not rostrate in front, and keeled on the back and sides. Abdomen of six segments terminated by an elongated, triangular and pointed telson; segments arched; pleura smooth, not expanded nor lobed; their extremities rounded. Sixth segment bearing caudal flaps, one on each side, composed of five visible elements, the outer four apparently anchylosed to form a single large triangular plate on each side of the telson. Thoracic ambulatory appendages elongated, smooth and filiform, except the upper (second) joint, which is laterally compressed. Abdominal appendages short, the upper joints flattened or convex anteriorly, as if for the attachment of plates or fimbria. Antennæ with the basal joints strong and well developed, of large size, much exceeding in strength any of the thoracic limbs. Eye-peduncles short. Type *P. Newberryi* Whitf.

This is, so far as I am aware, the most ancient Decapod crustacean yet recognized, and on that account alone is of great interest. The character of the caudal plates, in having the parts combined to form a solid plate on each side of the telson, is also an interesting feature, if rightly understood. From the impression of the plate as seen on the ventral side, it was at first supposed to be of a single element only, but on obtaining an impression in the fragment of rock, chipped from the top or dorsal surface, the obscure lines of the first and second joints were detected, while the outer three are only traceable from the very slight difference in the surface character of two of them, and the thickened substance of the third or marginal one. Of the thoracic limbs only parts have been seen, and of the abdominal members the three anterior ones on one side; the others being concealed by the rock. The abdominal appendages are inclined backward from their point of origin, while in most of the allied living forms as *Atyoides*, *Regulus*, *Pandalus* and others, they are inclined in the opposite direction; but this is not necessarily of importance. The eye-stalks appear to have been very short, judging from the spherical cavities beneath the anterior extremity of the carapace, which are small, close together and shallow.

The earliest form of Decapod crustacean previously described, so far as I can ascertain, is given by Mr. Salter in the Quart. Jour. Geol. Soc. London, vol. xvii, p. 531, 1861, as *Palæocrangon socialis*, said to be from the Lower Carboniferous limestone of Fiefshire, Scotland. There is another supposed Decapod, *Gitocrangon*, noticed by Richter (Beiträge Paleont. Thuring.), from the Upper Devonian, which is mentioned by Salter, but of which he says he is doubtful if it be a crustacean at all. I have not seen the work in which the original description occurs, and can only judge of its nature from Mr. Salter's remarks.

PALÆOPALÆMON NEWBERRYI, n. sp.

Body slender, the carapace forming a little more than one-third of the entire length, higher than wide, narrowed anteriorly and truncate behind; being longer below than above; median line carinate, with a second carina on each side a little below the crest; anterior end not rostrate but obliquely truncate, and sloping rapidly backward above the truncation, forming, when looked upon in front, a narrow, elongated shield-shaped and slightly depressed area, obtusely pointed above and rapidly widening at the base, the lateral carinæ rising from the lower angles; lower posterior angles rounded; basal margins gently curved throughout and bordered by a narrow, thread-like band with a narrow groove within it. Abdomen moderately robust, highly arched along the dorsal line, the

pleura curving inward below, giving a cylindrical form. Pleura broadly rounded at their extremities on the anterior face, but slightly angular on the posterior corners; posterior margin of the segments strongly arching forward on the back. Telson elongate triangular, a little less than twice as long as wide, somewhat angular above and marked by a central ridge below, and by a backward curving, transverse ridge across the widest part. Caudal flap large, forming a triangular plate on each side, the first and second joints short sub triangular; marginal plate of the flap thickened, narrow and elongate; central plate narrowly triangular, a little longer than wide: third or inner plate of equal length with the second and a little wider than the marginal one; the three combined as one, being apparently anchylosed at their margins to form a solid piece. Antennæ very strong, the first joint half as long as the thorax, slightly swollen in their lower half, and flattened on the under side; the other portions unknown. Thoracic limbs very slender and only of moderate length, the second joint laterally compressed, making the height nearly double the width; other joints apparently cylindrical. Abdominal limbs known only by their second (?) joints, which appear to be triangular in form, widening below, flattened and plate-like in character or slightly convex on the anterior face. (In one case only, a single thread-like appendage can be seen, as if projecting from the outer lower angle.)

Surface of the carapace marked by very fine, tortuous and interrupted, raised lines, strongest anteriorly and running obliquely upward and backward; also by a single slender, distinct, raised ridge, extending more than one-fourth the length of the carapace, originating at the lower anterior angle and passing upward and backward, with a bifurcation at the anterior third of its length. Surface of the abdomen essentially smooth. Caudal flaps marked by impressed lines increasing in number and fineness from above downward.

ART. VII.—*Upon an Optical Method for the Measurement of High Temperatures*; by E. L. NICHOLS, Ph.D. (Göttingen).

IN a previous paper* a series of experiments upon the nature and intensity of the light emitted by glowing platinum were described. It is proposed in this article to discuss more fully the results then obtained, and to develop from them, so far as is at present possible, an optical method for the measurement of

* On the Character and Intensity of the Rays emitted by Glowing Platinum, vol. xviii, Dec., 1879.

high temperatures. This method depends upon our ability to obtain, from results such as are recorded in Table IX of that paper, a general expression for the radiating power of any given body as a function of the temperature, or, what amounts to the same thing, to find the values of the quantities, A, E and I, in Kirchhoff's equation

$$e = \frac{E}{A} = I\frac{w_1 w_2}{s^2} \qquad (1)$$

These quantities being given, the temperature of a source of light could be determined by comparing the intensity of portions of its spectrum—as for instance those lying between λ and $\lambda+d\lambda$, λ' and $\lambda'+d\lambda'$, λ'', and $\lambda''+d\lambda''$, &c.—with the corresponding wave lengths of the spectrum of a body of known temperature and of known emissive and absorptive capacity. Here, as in my former paper, are to be understood by the terms "absorptive and emissive capacity," the qualities A and E, as defined by Kirchhoff.* Such a method, even though its accuracy be limited to that attainable in other spectrophotometric determinations, would bring into the field of quantitative research, a domain in which, so far as temperature is concerned, accurate measurements have been hitherto unattainable.

M. Crova, in *Comptes Rendus*, has suggested a similar method. He gave, however, no measurements of glowing temperatures upon which to base his method, and ignored entirely the very serious difficulties to be overcome before it can be made practically available. M. Crova proposes the following three modes of procedure:

1. "Au moyen de la longueur d'onde de la radiation qui limite le spectre vers le violet."†

2. "Par la position du maximum calorifique du spectre qui se rapproche d'autant plus du violet que la température d'émission et plus haute."

3. "Au moyen du rapport de l'intensité lumineuse d'une radiation determinée λ, pris dans le spectre de la source, à l'intensité de cette même radiation du spectre d'une source de température connue, comparée au rapport des intensités lumineuses d'une autre radiation λ' dans ces deux mêmes spectres."

". . . . La mesure vigoureuse des températures pourra être faite par voie spectrometrique des que l'on connâitra la loi exacte de l'émission pour toutes les radiations et des constantes numériques pour chaque longueur d'onde. . . . ."

In the first method, the visible spectrum is falsely assumed to have a clearly defined boundary at its end nearest the violet.

* Kirchhoff. Untersuchungen über das Sonnenspectrum, Anhang, § 2.

† Crova, Etude spectrométrique de quelques sources lumineuses; Comptes Rendus, lxxxvii, 322.

In point of fact the "*limit of the spectrum*" admits (see vol. xviii, p. 400) of no sharp determination, depending as it does upon the constantly varying condition of the observer's eye.

If, as is commonly supposed, the position in the spectrum of the thermal maximum were a function of the temperature, the second method would be at best practically applicable to but a few of the most intense sources of light. Some recent discoveries of Dr. Jacques in Baltimore,* seem to show that the position of the thermal maximum depends upon the molecular weight of the glowing body, and that, for a given source of light, its position is in no way affected by a change of temperature. This newly discovered fact renders Crova's second method useless. I shall show presently that aside from Jacques' experimental evidence there are good reasons for supposing the position of the thermal maximum to depend upon the nature of the glowing body rather than upon its temperature.

The third method coincides with that which I have proposed. The chief difficulty in the development of it lies in the varying values of the emissive and absorptive capacity of different bodies.

In Equation (1) the fraction $\frac{E}{A}$ is to be sure independent of the nature of the body in question; not so, however, the quantities E and A, considered separately. That A, possesses for different substances widely different values we know from former researches. Hitherto, however, these experiments have been confined to ordinary temperatures, and the question of the dependence of this quantity upon the temperature has been for the most part neglected.

For the purposes of general discussion it is convenient to divide all bodies into four classes.

I. Bodies for which A=Constant, for all wave lengths and for all temperatures.

II. Bodies for which A varies with the temperature, but has the same value for all wave lengths.

III. Bodies for which A varies with the temperature and possesses different values for different wavelengths, but for which the ratio of these values in any two spectral-regions λ to $\lambda+d\lambda$ and λ' to $\lambda'+d\lambda'$ is independent of the temperature.

IV. Bodies for which A varies with the temperature and wave length and for which the above-mentioned ratio is also a function of the temperature.

Black bodies are, by definition, of the first class. Whether bodies exist for which A=Constant <1, can only be determined by special experiment. To the second class belong

* Distribution of Heat in the Spectra of various sources of Radiation. Cambridge, 1879.

bodies which absorb all colors in equal proportion. They appear colorless when nearly transparent, white or gray when opaque, according to the intensity of the light falling upon them and to their reflecting power. That many transparent bodies belong to this class and not to class I, is evident from the fact that although they remain transparent and colorless at temperatures above that at which metals are red hot, it is possible by heating them still further to cause them to glow brightly. Such a change in the power of emission corresponds to an increase in absorptive capacity.

That in general the absorptive capacity of other than black bodies cannot be a constant quantity may be inferred from the usual equations for the intensity of the reflected ray. Let the body in question be opaque. Of all rays falling upon it one portion will be reflected, the remainder absorbed. It has however been proved that such bodies are in general transparent when taken in sufficiently thin layers. The rays must therefore instead of being converted into heat at the surface, force their way to a certain depth into the interior of the body, and we are justified in assuming that refraction occurs. Let r be the angle of refraction, and i the angle of incidence of a certain pencil of light falling upon the substance. Let the intensity of the incident ray $= 1$. Whatever the character of its vibrations—provided only that in accordance with the accepted theory they be transversal—the ray can be resolved into two components, the one polarized in the plane of incidence, the other perpendicularly to it. Let e_p and e_s be the amplitudes of these components the intensities of which are denoted by f_p and f_s. Then

$$f_p = e_p^2, \quad f_s = e_s^2;$$

The amplitudes of the reflected portion of the component e_p will be

$$B_p = e_p \frac{\sin(i-r)}{\sin(i+r)} \tag{2}$$

and its intensity,

$$R_p = f_p \frac{\sin^2(i-r)}{\sin^2(i+r)} \tag{3}$$

The amplitude of the other part of the reflected ray will be

$$B_s = e_s \frac{\operatorname{tang}(i-r)}{\operatorname{tang}(i+r)} \tag{4}$$

and its intensity

$$R_s = f_s \frac{\operatorname{tang}^2(i-r)}{\operatorname{tang}^2(i+r)}. \tag{5}$$

The expressions (3) and (5) approach 0 as a limit when the values of r and i are made to approach each other. In other words, when the optically denser medium becomes less dense

the intensity of the reflected ray diminishes, and a larger portion of the incident ray is absorbed.

We know that in the case of liquids their refractive index increases with their physical density, and that generally it changes for other bodies with change of temperature. The change in the index of refraction is however equivalent to a change of optical density and of the quantity $(r-i)$; so that we may expect, for all bodies for which Fresnel's formula holds, a change in the intensity of the reflected ray and consequently of the absorptive capacity for every change of temperature.

Those substances, at the surfaces of which so-called "metallic reflexion" occurs, are not included int his argument, since the formulæ do not apply to them. They would have to be considered in the lack of further knowledge as possible exceptions to the law.

For such bodies MacCullagh,* making use of the hypothesis of an imaginary angle of refraction, assumed for r the following expression:

$$\sin r = \frac{\sin i}{m}\cos\chi + \sqrt{-1}\sin\chi. \tag{6}$$

$$= \frac{\sin i}{n}(\cos^2\chi + \sin^2\chi)$$

which admits of the common definition of n

$$n = \frac{\sin i}{\sin r},$$

since even for an imaginary angle,

$$\cos^2 r + \sin^2 r = 1.$$

In a similar manner MacCullagh assumes

$$\cos r = \frac{\cos i}{m'}(\cos\chi' + \sqrt{-1}\sin\chi'), \tag{7}$$

where m' and χ' are functions of m and χ.

Substituting these values in equation (3) we obtain,

$$R_p = {}_pf\,\frac{(m'^2 - m^2)^2 + 4m'^2\,m^2\sin^2(\chi-\chi')}{(m^2 + m'^2 + 2m'\,m\cos(\chi-\chi'))^2}$$

To cause R_p to disappear we must set $m=m'$ and $\chi=\chi'$. MacCullagh determined experimentally the values of m and χ, but I know of no researches from which to draw any conclusions concerning the influence of temperature upon these quantities.

Cauchy† gives for R_p the following expression,

$$R_p = f_p\,\frac{\sin^2(i-r) + \gamma^2\sin^2 r}{\sin^2(i+r) + \gamma^2\sin^2 r}, \tag{9}$$

* MacCullagh, Proceedings of the Irish Academy, i, 2, 159; ii, 375.

† Cauchy; Comptes Rendus, ii, 427; viii, 553–658; ix, 727; xxvi, 86.

naking use of the hypothesis that the intensity of the efracted ray within the metal, diminishes in geometrical progression from the surface inward. Here as in the equations or ordinary reflected light, R_p depends upon the quantity in $(i-r)$. In what manner r is influenced by change of temperature has never been experimentally determined.

I have found, experimentally, the value of A for platinum it 1650° C (of the Pt. thermometer). At this temperature the pectrum afforded by glowing platinum is similar as regards he relative intensity of its various wave lengths to that of the lame of a petroleum lamp. Such a lamp-flame, the luminous ays being emitted by hot particles of carbon, answers most iearly of any available source of light the definition of a black ody glowing at a constant temperature.

A flame of this kind is far from being opaque. It is quite possible under proper conditions to read fine print through it, o that in this respect the flame differs from a perfect, "*black ody.*" I measured in the following way the transparency of the etroleum flame which I wished to use in the experiments ibout to be described.

Suppose such a flame to be brought into position before the pectrophotometer so that a certain pencil of rays would fall ipon the slit. Were the flame perfectly transparent, a second recisely similar one and equally bright would, if placed beiind the first flame, double the intensity of the above menioned pencil of rays. Were on the other hand the first flame erfectly opaque, all rays reaching it from the second flame vould be cut off, and the light arriving at the slit would suffer io increase in brightness.

The nearest approach to a second precisely similar flame is he real image of the first one. This image would be, when of the same size, of weaker intensity than the flame itself; but its other properties should, provided the mirror absorb all wave lengths of light in equal proportion, coincide perfectly with those of the flame.

I illuminated both halves of the slit of the spectrophotometer with two common petroleum lamps with *flat* burners. Before the lower flame, was adjusted a system of cross-wires, of which the horizontal ones appeared as dark lines in the polarized spectrum. By means of these it was easy to tell which portion of the flame came into the field of vision. Behind this lamp I placed a concave mirror, so that a real image of the flame was cast upon the flame itself. This image was of the same size but weaker than the flame. Since the horizontal wires appeared in the spectrum of the image as well as in that of the flame, forming another set of black lines, it was possible to adjust the mirror so that corresponding portions of flame and

image coincided. The spectrum formed by the two combined was much brighter than that of the flame alone, and it was easy, having measured the increase of intensity due to the image, to calculate how much of light reflected by the mirror and falling upon the flame, was absorbed, and how much allowed to pass through it. In making this calculation it was necessary to know: the reflecting power of the mirror, the transmitting power of the lamp chimney, and the relative intensity of the spectrum of the flame to that of the flame and image combined.

First of all the transmitting power of the lamp-chimney was investigated. The lamp having been provided with an exactly similar chimney, the spectrophotometer adjusted and the spectrum of this lamp flame having been compared with that of the flame lighting the upper half of the slit, the chimney to be examined was suspended in the path of the rays between the flame and slit, whereupon the spectra were again measured. I found that the chimney permitted the passage of 0·8573 of the light. Then the mirror was taken in hand. The lamp being moved a few centimeters to one side and the mirror turned until the image of the flame occupied the former position of the flame itself; the intensity of the resulting spectrum was measured. This gave as illuminating power of the image, 0·6509 of the flame's intensity. The lamp was then restored to its place before the slit and the mirror readjusted until those portions of the flame and image which appear in the spectral image coincided. The spectrum of this double source of light was then measured, and by repeated intervention and withdrawal of a black screen between the lamp and mirror, compared with the spectrum of the flame above. I found the ratio of flame and image combined to the flame alone, to be 1·2075 : 1. Had both flame and lamp-chimney been perfectly transparent, this ratio would have been 1·6509 : 1. The effect of the lamp-cylinder being eliminated the remaining difference is naturally to be attributed to the absorptive capacity of the flame; and we find $A = 0{\cdot}6432$.

To determine the value of A for platinum at the temperature in question, it only remained to compare the radiation of a glowing platinum wire with that of the flame. The wire having been given a temperature of 1650° (Pt. thermometer) for which the leucoscope* showed that the quality of the light emitted corresponded precisely with that from the petroleum-flame, the intensity of its spectrum was measured and found as compared with that of the flame to be as 1·198 : 1.

The value of A for platinum at this temperature is accordingly, $A = 0{\cdot}7597.$

* For the method by which the platinum wire was made to glow, and for a description of the leucoscope, see Paper I.

De la Provostaye and Desain* give as the reflecting power of cold platinum for lamp light (unpolarized), 0·677, so that for this metal when cold, $A = 0·323$.
The difference between these values is so large, that making all reasonable allowance for the inaccuracies of both researches it seems certain that *platinum at 1650° has a much greater absorptive power for the rays of the visible spectrum than at ordinary temperatures.*

This experiment shows that platinum at least, of those substances affording metallic reflexion, offers no exception to the general law deduced for other bodies, viz: that A and E are functions of the temperature. The nature of this function, and the dependence of A and E upon the wave-lengths of the rays in question must be made the subject of special and extended investigation. It is an unexplored domain. Almost the only researches which give substance for a probable surmise, are those of Jacques already mentioned. The fact that the position in the spectrum of the maximum of thermal intensity is a function of the nature of the glowing substance and independent of its temperature, points to the conclusion that *solid bodies belong to the first three classes.*

The effect of temperature upon the spectra of gases has already, thanks to the interest lent to this subject by its importance in Spectrum Analysis, attracted much attention, and the existing researches admit of no doubt that in general *the gases belong to the fourth class.*

The steps necessary to the application of the results of the first article to the proposed method of measuring high temperatures are now evident. A general law for the changes of the quantity A must be experimentally determined, or failing in this, its values found for the various glowing bodies it is most desired to measure. It will then only remain to subject the results in Table IX (Paper I) to a further reduction so that they may be made to express the effect of temperature upon the rays from an ideal "black body" instead of those emitted by glowing platinum; and finally to obtain a satisfactory comparison of the platinum thermometer with the scale of the Centigrade air thermometer. Experiments to this end are in preparation by the author.

Peekskill, New York, July 1, 1879.

* De la Provostaye et Desain, Comptes Rendus, xxxi, p. 512; also, Annales de Chimie et de Physique, III, xxx, 276.

ART. VIII.—*Recent Explorations in the Wappinger Valley Limestone of Dutchess County, New York*; by Professor W. B. DWIGHT, Vassar College, Poughkeepsie, N. Y.

No. 2.—CALCIFEROUS AS WELL AS TRENTON FOSSILS IN THE WAPPINGER LIMESTONE AT ROCHDALE AND A TRENTON LOCALITY AT NEWBURGH, N. Y.

HAVING made further explorations in the limestone of the Wappinger Valley, since the publication of my former article,* I now present some of the new results obtained; and first those at Rochdale. Before doing this I would express my great obligations to Mr. R. P. Whitfield and Mr. S. W. Ford, for their cordial assistance in advising me concerning fossils of whose nature I was not confident, and in naming several which I had failed to identify.

In my former paper, I mentioned finding at Rochdale fossils of the Trenton limestone, whose names, as far as identified, were given. I have now to report the discovery also of Calciferous fossils in the Rochdale limestone belt, besides adding to the facts respecting the Trenton fossils.

The Chætetes of the Rochdale Trenton beds, composed of extremely fine columns, described as probably new, and for which the name *Ch. tenuissima* was suggested, has since been identified as in part, at least, *Stromatopora compacta* of Billings,† which Dawson has shown to be a *Chætetes*, and has named *Ch. compacta*. Since, however, the greater part of the specimens observed at this locality, although extremely fine-columnar, are yet decidedly and uniformly coarser than the particular specimens (from Pleasant Valley) which were thus identified, and as microscopic sections, which are under study by myself and others, promise to show other constant differences, I do not yet abandon the name proposed, as it may still cover the majority of these corals. I leave the subject until further investigation shall enable me to report upon it more decisively.

In addition to my former list of Trenton fossils from Rochdale, I have secured quite a number of Cyathophylloid corals: and among them, with little doubt, *Petraia corniculum*, in some specimens of which the radiating lamellæ are very well defined. I have also obtained several more specimens of *Leptæna sericea*; a large number of *Orthis pectinella*, and others which are probably *O. tricenaria*; a caudal shield of a trilobite, which has been identified by Mr. Ford as *Illænus crassicauda*, and is nearly two-thirds the size of the largest specimen figured by Hall;‡ and

* This Journal, May, 1879. † Pal. Foss., 1862, vol. i, Black River Group.
‡ N. York Geol. Rep., Pal., vol. i, Pl. 60.

a head of *Echino-encrinites anatiformis*, distorted, which must have been nearly two centimeters in horizontal diameter. The star-shaped *rays*, discernible on some of its plates, leave hardly a doubt as to its being the species mentioned, which occurs, as I have certainly found, at another locality mentioned beyond.

The *Chætetes compacta* (?) exists here in remarkable abundance, sometimes forming masses as large as a human head or larger. The *Chætetes lycoperdon* has not yet appeared in any of its forms. The abundant encrinal columns are of the small size usual in this limestone; one of them is one decimeter long and seven millimeters in width.

I have already mentioned my discovery at Salt Point, in the same Wappinger limestone belt, six miles northeast of Rochdale, and four northeast of Pleasant Valley, and also at another place two miles northeast of Pleasant Valley, of numerous univalves coiled nearly in a plane, and of small and delicate Orthocerata. Lately I have found abundant outcrops of the rock containing these fossils at *Rochdale*, in close contiguity to the Trenton exposures.

Further study of these fossils, in consultation with the able paleontologists mentioned above, with the finding of additional species, enables me to report essential progress in the study of these crystalline strata. The rock containing these fossils, wherever found, differs as a mass lithologically from the Trenton rock at the Rochdale exposure, and the difference is so marked that, as they lie apparently side by side at Rochdale, with conformable dip, the two kinds of strata are readily distinguished by a passing glance. While such lithological differences are not to be pressed as to rock-masses where these are separated by great distances, they may be of great importance, even in spots where fossils happen to be absent, in studying the rocks of a limited neighborhood. The Trenton rock here is of a dark bluish color, massive, but with some shaly portions, and generally very distinctly crystalline—that is, when it is broken, sparkling with crystalline facets about one or two millimeters in diameter. Though somewhat siliceous and traversed occasionally by siliceous veins, or containing hornstone nodules, it is neither eminently arenaceous nor closely intersected with flinty veins. Its weathered surface is simply the ordinary gray of weathered limestone. The other limestone rock, and the predominating rock of this region, is however, in general, several shades lighter than the Trenton, often of a "dove" color; it is uniformly fine-granular in structure, with visible crystalline facets an exception; and it is traversed to a remarkable degree with either an angular network of siliceous seams, or a twisted, curved, and knotted network, always suggesting fucoids, and very frequently showing an undoubtedly fucoidal nature.

Moreover its weathered surface is almost invariably white (frequently as much so as white lead), and highly arenaceous; and its fossils are, when weathered, of the same character. The fracture is apt to be much more splintery and conchoidal than that of the Trenton beds.

The fossils which in several places abound in this lighter-colored rock, do not leave us in doubt as to its nature. I have found specimens of the following identified specimens:

Ophileta complanata. This species is found at Wallace's quarry, Salt Point, and is one of the coiled univalves of that place mentioned, but not identified, in my previous article. It occurs also at the railroad cut two miles northeast of Pleasant Valley, and abundantly at Rochdale. In general appearance it resembles the figure given by Vanuxem in his New York Geological Report (p. 30), though it is often larger and more delicate in its structure than the somewhat rough figure represents. It is possible that this may be the *O. compacta*, the two species differing so slightly that some authors (as Billings*) suppose them to be only varieties of the same.

Ophileta levata. This is less numerous than the preceding, but is quite as well marked. It is found at Salt Point, and at Rochdale.

Ophileta (Maclurea) sordida. A number of specimens occur at both localities last mentioned. The ellipsoid form which induced Vanuxem to call the species Ellipsolites leaves little room for doubt.

Orthoceras primigenium. I have found perhaps a dozen specimens of this Orthoceras, all quite well marked; and from the indications of fragments, should say that it is rather abundant at both localities, but especially at Rochdale. The numerous, delicate, considerably curved septa are very distinct. Some of my specimens are from two to three inches long. In every instance they are shown in nearly central longitudinal sections.

There are other univalves like *Ophileta*, or *Helicotoma*, which I have not yet made out; and some smaller Orthocerata. The univalves from Salt Point, previously described as apparently containing septa, and which I supposed therefore might be Trocholites, are probably *Ophileta* (*levata ?*) as the septa prove to be false.

These fossils often occur within the meshes of a network of fucoidal fronds, which, at Rochdale at least, assume a more or less tubular form for the stems. These may be *Buthotrephis antiquata*, but are too indistinct to be identified satisfactorily. This rock does not contain the abundant Chætetes, the encrinal columns of the contiguous Trenton, nor any other of the fossils found in that stratum.

* Geol. Can., vol. i, p. 246.

The conclusion is unavoidable that the rock in question is Calciferous; and it is probable that the portions containing the *Ophileta* are the "fucoidal layers" of the upper part of the formation. The description of these layers given in Vanuxem's Report (p. 30) applies exactly to those of Dutchess County.

In carrying my investigations lately to the continuation of this limestone belt across the Hudson River, I received information from Mr. J. N. Weed, Cashier of the Quassaic Bank of Newburgh, N. Y., of a fossiliferous locality near that city. It has proved to be very rich in fossils, both as regards number and variety. Their presence here has certainly been known to one prominent geologist; but it was evident that no careful examination had been made, as there was scarcely a mark of a chisel, and the most interesting specimens had been left undisturbed. The locality is 2¾ miles north from the Newburgh ferry, on the road leading to the brick-kilns on the river, and opposite to the property of Dr. W. A. Culbert. The place is between four and five miles in a northeasterly direction from the quarry (D. Miller's) where R. P. Whitfield discovered, in July last, specimens of *Maclurea magna* of the Chazy. It is a sloping rock-face about twenty feet high and two or three hundred feet long, directly on the road, at the point where it first comes in sight of the river. The rock is a dark crystalline limestone with the dip easterly 40°, and the strike N. 35° E. It is a mass of small encrinal columns and of fine Chætetes. One of the most remarkable features is the presence of many specimens (I have collected about twenty), of an unusually large encrinal column for this geological horizon, and one never collected (I believe) in this State before. It is from one-half to three-fourths of an inch in diameter, and has been identified by Mr. S. W. Ford as *Cleiocrinus magnificus* Billings, hitherto a Canadian fossil only.

I have also found here the following fossils which are unmistakably identified (except for doubts already stated as to *Ch. compacta.*)

Orthis Lynx, several; *Orthis pectinella*, many; *Rhynchonella capax*, several; *Leptæna sericea*, several; *Strophomena alternata*, abundant; *Discina*, new species, many; *Chætetes compacta*, very abundant; *Chætetes lycoperdon*, var. *ramosus*, abundant; columns of *Schizocrinus nodosus*, abundant; head-plates of *Echinoencrinites anatiformis*, abundant.

In addition, there are probably the species *O. tricenaria* and *Petraia* (*Streptelasma*) *corniculum*, with pentagonal crinoidal columns, and some brachiopods too indistinct perhaps to be identified.

The *Discina* is one to one and a half centimeters in diameter, with an unusually conical lower value, and a nearly flat upper

one, the peduncular groove being in the conical valve. As it is evidently new, I propose for it the name *D. conica*, and reserve a full description of it, and further remarks on the locality, for another paper.

These developments establish this beyond doubt as a stratum of the Trenton limestone.

ART. IX.—*On the first Results from a new Diffraction Ruling Engine;* by WILLIAM A. ROGERS.

THE best diffraction gratings are subject to three classes of errors:—

First. The accidental errors of single subdivisions, which are, for the most part, due to the irregular motion of the ruling diamond upon a non-homogeneous metal.

Second. The periodic or systematic errors, which are a function of one revolution of the ruling-screw.

Third. Errors which depend upon the position of the nut upon the screw, and which are equivalent to a varying pitch of the screw.

The errors of this class may be due either to the form of the screw itself, to a variation in its diameter, or to an imperfect mounting of the screw. The pitch of even a perfect screw practically undergoes a slight change with every variation of the amount of the friction between the moving parts of the ruling-engine.

Let us take as a type, the magnificent rulings of Mr. L. M. Rutherfurd, executed by Mr. D. C. Chapman. These gratings easily surpass all others in their resolution of the lines of the solar spectrum. Here, the first class of errors is so far wanting that it is safe to say of a given space, that it is so nearly equal to its neighbor that the most rigid investigation with the microscope will fail to reveal any difference.

For separate, narrow and adjacent spaces then, a well-made, and well-mounted screw is subject to less liability to error than the microscopic observation with which the comparison is made, even under the manipulation of the most skillful observer.

With regard to the second class of errors, viz: those which are a function of one revolution of the ruling screw, it is to be said that the danger of their occurrence is far greater. Indeed, I am not aware that they have ever been entirely overcome. In the measures of single narrow spaces they easily escape detection. For example, suppose we have a screw having a pitch of one-twentieth of an inch, in which the first half of one revolution differs from the second half by one ten-thousandth of

an inch. Each half will then have an error of one twenty-thousandth of an inch. But this maximum value is made up of successive increments of very minute errors, starting with the zero of revolution. If the graduations are ten thousand to the inch, there will be five hundred spaces in half a revolution of the screw. This maximum value, then, of the twenty-thousandth of an inch, a quantity easily measured, will be made up of five hundred additions of the errors of the successive individual spaces. If the error is a constant one for each space, its value will therefore be only one ten millionths of an inch, a quantity far beyond the ultimate limits of measurement with the microscope. When, by one hundred successive additions, the error amounts to one hundred thousandths of an inch, it will then be barely within the limits of detection.

In Mr. Rutherfurd's screw the errors of this class are nearly overcome by giving an excentricity to the index of the screw, sufficient to neutralize them at the quadrant points of revolution; that they are not entirely eliminated is shown not only by the actual measurement of distant lines, especially at the octant points of revolution, but also by the fact that the surface-waves, resulting from the residual systematic errors, are easily seen with the unaided eye when the gratings are examined with a monochromatic flame.

In the investigations of the wave lengths of light hitherto made, no attention has been paid to the periodic errors which are a function of one revolution of the ruling-screw. Our present knowledge of wave lengths depends on the supposition that the gratings from which they were determined are homogeneous throughout their whole extent. If I am not mistaken, both Ångström and Van der Willigen, who have done the best work in this direction, obtained the value of one interval by dividing the distance between the end lines by the number of spaces. It is at least possible that the error introduced through the neglect to take into account the varying pitch of the screw, may be of appreciable magnitude. I can now only note in this connection, that when oil or grease is used as a lubricant, the curve which represents the periodic errors usually has a perceptibly different form for each revolution. The compound error thus developed introduces a class of secondary systematic errors analogous to those described under the third class.

After a somewhat careful study of these three classes of errors in connection with the ruling-engine constructed for me by Buff & Berger of Boston, I determined, about two years ago, to attempt the hazardous and costly experiment of constructing a new machine which should be capable of producing a grating homogeneous throughout its whole extent. In the execution of this work I was more than fortunate in securing

the coöperation of Mr. Chas. V. Woerd, the mechanical superintendent of the Waltham Watch Factory. My warmest thanks are also due to the manager and treasurer of the Company, Mr. R. E. Robbins, for consenting to undertake a task somewhat outside of the regular work of the factory.

To Mr. Woerd I committed the entire arrangement of the details of the new machine, after deciding upon the general principles of its construction.

The new machine is now so nearly completed that some provisional work has already been done with it. It would be premature to say that it will rule a grating absolutely without measurable errors. The resolution of solar lines must be the final test, and the decision on this point I must leave to those who may use the gratings which I hope soon to make.

I venture the assertion, however, that it is the most perfect piece of work done in this country, and I doubt if its superior is to be found abroad. I feel the more free to say this because the credit for the execution belongs entirely to Mr. Woerd and to Mr. George F. Ballou who has done nearly all of the work. This is not the place for a detailed description of the machine. I will only state the general principles on which it is constructed.

(*a.*) In the usual construction of a precision-screw, it is the custom to grind and polish the threads with fine emery by means of a lead nut, after the thread has been cut as perfectly as possible in the lathe. A definite relation then exists between the threads and the centers on which they are cut. Now in grinding and polishing, the lead nut is usually held by the hand as it traverses forward and backward, and the test of the uniformity of the threads is entirely one of feeling. But during this operation *the relation between the threads and the centers may be entirely changed*, since the action of the lead nut no longer bears any fixed relation to the centers. Hence when the screw is mounted with respect to its centers, we may always expect systematic errors of various kinds.

In the construction of the screw of the Waltham machine, an attempt has been made to avoid the errors introduced in this way. The bottom of the thread was, at the suggestion of Mr. Woerd, entirely cut away, giving entire freedom in the action of the emery upon the faces of the threads. The screw rests in semi-circular bearings, and is kept in position by its own weight. The conical ends are made of tempered steel. One end presses against a polished diamond face ground exactly perpendicular to the axis of the screw. It is kept in contact by means of a steel spring bolt working against the other end. The nut is made a part of the moving bed-plate, and rests directly upon the screw.

Usually the aliquot part of a revolution of the screw is, g the process of ruling, secured by means of a pawl act- ıpon the teeth cut upon the index. In this case one is ed to certain fixed arcs of revolution. In the Waltham ine a magnet-arm 24 inches long rests upon the axis of the '. The end of the arm works between two movable stops. ıgnet fitted to the curvature of the index is attached to the end. Another magnet is attached permanently to the bed e machine beneath the index. During the upward move- of the magnet-arm, the first magnet becomes firmly hed to the index, carrying it forward, an arc of revolution nding on the distance between the stops. During the ıward movement of the arm the index is held in position ıe second magnet.

will be seen that the arc of revolution may be made to at will between zero and a value limited by the greatest nce between the stops, which in this case corresponds to a on of a little over one thousandth of an inch in the screw-

ıe index of the screw regulating the distance between the reads directly to about one millionth of an inch ex- ed in the corresponding motion upon the ruling screw. these divisions can be estimated to tenths, as small a ment as one ten-millionth of an inch can be given to the r-plate with entire certainty *as far as the mechanical indica- of this degree of precision are concerned.*

) In order to provide for the neutralization of whatever s might be found to exist in the screw in actual use, the wing devices were adopted :—

) Instead of allowing the magnet-arm to fall upon a fixed it falls upon a circular templet, having a motion in revo- n simultaneous with that of the index of the screw. A ıture is given to the periphery of this templet which tly corresponds to those measured errors of the screw h depend on one revolution.

) A straight templet runs parallel with the screw to which ven a curvature corresponding to those errors which de- upon the position of the nut upon the screw. This let is supported upon a vertical fulcrum placed near one Since the other end is movable between guides, it is ous that in effect the pitch of the screw can be varied at by an easy adjustment. In practice however it is found er to secure this result by varying the distance between the s of the magnet-arm.

he present indications are that neither of these supple- tal corrections will be found necessary.

(*d.*) In the investigations of wave lengths from a given ruled grating there are certain requirements which seem to need experimental as well as theoretical research.

First. It is important to ascertain the best relation between the width of the lines and the width of the intervening spaces. In this machine, after having obtained a good line of a given width, the width of the spaces can be varied at will.

Second. All we can say of the wave-length equation $\lambda = \epsilon \sin\theta$, is that it expresses the length of a single wave of light of a given color. When we take into consideration the conditions under which the waves reach the eye, it is at least an open question whether the form of the equation is not somewhat more complex. As an illustration, the law of refraction in passing from one thin stratum of atmosphere to its adjacent one is quite simple, but it does not follow that this law holds good for the combined strata which make up the atmosphere at a given altitude above the horizon.

In order to ascertain the effect of errors of any class upon the position of the solar-lines it seems important to determine the effect of these errors experimentally. Hence the machine has been constructed in such a way that it is possible to introduce at any point, either any single error of a given magnitude, or any combination of errors, without interfering with the remaining graduations.

The tremors communicated to the machine by the running-machinery of the factory prevent the best work; but the experiments already made justify the hope that when it is permanently mounted upon the firm foundation already prepared for it, work may be done which will contribute something to our present knowledge of wave-lengths. In this connection also, especial attention will be paid to the expression of all measured distances in terms of the standard Meter of the Archives at a temperature convenient for use. With this view a standard decimeter subdivided into 10,000 equal parts will be taken as the unit of comparison.

As a type of the character of the work already done I will close this article with a description of two glass plates ruled on different days with the same setting of the stops of the magnet-arm. The stops were set to correspond to a motion of one thousandth of an inch upon the screw. The machine was started at 10 o'clock A. M. Between 12 and 1 o'clock it remained at rest. It was also at rest during the night. Starting again at 7 o'clock the next morning it was stopped at $9^h\ 50^m$, having ruled 4001 lines, covering a space of four inches.

The plate was then removed, and another one was placed in position. The machine was again started, and this second plate was ruled under nearly the same conditions with regard to time and temperature as the first one.

Having filled the lines with graphite in order to obtain a .rper definition of the edges, these two plates were then placed e to face in a mounting of stiff balsam in the same direction that in which they were ruled. When the lines at one end re made coincident, not only were the other end lines coinent, but every one of the 4001 lines exactly overlapped its .ow. With a power of 300 I was unable to detect a single e of deviation from exact superposition.

This experiment merely showed that the machine would rule) plates exactly alike under the same conditions, but it gave indications with reference to the homogeneous character of graduations. But when the plates were placed face to face a direction *opposite* to that in which one of them was ruled, n, coincidence being made between the lines at one end, a t of the homogeneity was found in the coincidence of the naining graduations.

This coincidence seemed to be perfect for about two inches. that point there was an abrupt separation amounting to out one eight-thousandths of an inch. This deviation re-ained a constant for about one inch, when it began gradually diminish, and finally disappeared at about one inch and one-lf from the point where it first appeared.

This error is probably due to a change of temperature during e nights on which the machine remained at rest. It is rather rious, however, that the error should have taken this partic-ar form. It is not surprising that it escaped detection when e plates were arranged as first described. In the second case, e lines were barely separated, but the separation was suffi-nt to enable one to measure from center to center. In the st instance the overlapping of the edges was not sufficient to ract attention.

Iarvard College Observatory, October 28, 1879.

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rt. X.—*Solar Parallax from the Velocity of Light;* by D. P. Todd, M.A., Assistant Nautical Almanac.

The opposition of Mars in 1862, and the experimental deter-nation of the velocity of light by Foucault in the same year, ırk the beginning of a new era in the history of the deter-nation of the solar parallax. Especial prominence has ached to the subject ever since, not only from its inherent ıportance, but also from the rapidly multiplying determina-ons of this constant which have been made, and the vigor of scussion that has been everywhere prevalent in scientific stronomical circles.

If the generally accredited theories of the solar parallax and inter-related facts and phenomena are true, the better class of these determinations should yield values of the parallax in consistent harmony with each other—modified only by deductive consideration of the amount of accidental and systematic error with which they are severally affected. The well known fact, however, is that even the best of these determinations appear, at present, singularly and unaccountably discordant. The solar parallax, 8″·848, derived by Professor Newcomb nearly thirteen years ago, generally replacing Encke's value, 8″·57116, was regarded with caution, only because it was considered too small—the researches of Hansen, of Le Verrier, of Stone, and of Winnecke were thought to have defined the parallax far outside Newcomb's value. Within two or three years, however, the *paralluctic pendulum* has swung quite to the lesser extremity of its arc, until the true value of the solar parallax has appeared possibly below 8″·8—and that, too, with good reason. But a slight gravitation toward a central value is already beginning to show itself—and now, in reality, it is not at all possible to say that the mean equatorial horizontal parallax of the sun is so much as a hundredth part of a second different from the ancient figures, 8″·813 [27″·2 centesimal], adopted by Laplace in the Mécanique Céleste, and given by the first discussion of the Transits of Venus in 1761 and 1769.

The method of determining the solar parallax through the velocity of light, though dependent on the results of physical experiments conducted under necessarily limited conditions, has never given a value of the parallax at all inconsistent with a combination of the best of the purely astronomical determinations. And this consideration encourages indulgence of the hope that, at some time in the not far distant future, this method will define the solar parallax within very much smaller limits than astronomers have yet known. To show what the method is competent to at the present moment is the object of this paper.

I bring together all the determinations of the velocity of light which have at all the merit of trustworthiness.

I. Fizeau made the first experimental determination of the velocity of light, in 1849; his experiments, however, hardly signify more than the completion of the first great step of proving the determination to be a physical possibility. The first reliable determination was executed thirteen years later by Foucault. His work has never been published *in extenso*, but brief papers have appeared in the Comptes Rendus, vol. lv, 1862, and in Poggendorff's Annalen, vol. cxviii, 1863. The resulting velocity of light is 298,000 kilometers per second, in which Foucault expresses confidence to about one-six-hun-

dredth part. I think I shall not be regarded far wrong in assigning a probable error twice as great. This I do in consideration of the very unfavorable limitations under which the determination was executed, and quite independently of what has since become known.

II. The first determination by Cornu, related in the Journal de l'École Polytechnique, xliv cahier, vol. xxvii, 1874. The resulting velocity of light is 298,500^k±1,000.

III. The second determination by Cornu, related in the Annales de l'Observatoire de Paris, Mémoires, tome xiii, 1876. The resulting velocity of light is 300,400^k±300. Helmert has given a rediscussion of these experiments in the Astronomische Nachrichten, vol. lxxxvii, 1876. His interpretation assigns the velocity 299,990 kilometers, the probable error of which I have estimated at 200 kilometers.

IV. The first determination by Master A. A. Michelson, U. S. Navy.* The resulting velocity of light is 300,100 kilometers. I consider this determination of equal weight with that of Foucault, and with the first determination by Cornu.

V. The second determination by Mr. Michelson. The number of this Journal for November, 1879, contains a brief recital of these experiments. I shall adopt, for the purposes of this paper, the results given on the "corrected slip," for his second determination of this constant of velocity.

The largest result for velocity of light, 300,142 kilometers.

The smallest result for velocity of light, 299,692 kilometers. Giving equal weight to the one hundred separate determinations, the resulting velocity of light is 299,930 kilometers per second. I find that the computed probable error of this determination is no larger than six kilometers. But, in the determination of almost no other astronomical or physical constant should we consider the computation of probable error of the final result from a corresponding number of observations quite so illusory. In consideration of all the sources of error, accidental and systematic, I think the probable error of this result may be estimated at 100 kilometers.

All these several determinations of the velocity of light are now combined as follow:—

I.	298000 ± 1000	Weight 1
II.	298500 ± 1000	1
III.	299990 ± 200	25
IV.	300100 ± 1000	1
V.	299930 ± 100	100

The resulting most probable velocity of light is

299,920 kilometers = 186,360 miles per second.

* Proceedings of the American Association for the Advancement of Science vol. xxvii, 1878.

The next step is the combination of this value with astronomical constants, for the determination of the distance of the center of the sun from the center of the earth.

(I.) Theory and observation of the satellites of Jupiter afford a determination of the time-interval required by light in traversing the mean radius of the orbit of the earth. Only two astronomically precise determinations of this interval have ever been made: the first, by Delambre, in the early part of the present century,* from a discussion of an immense mass of eclipses of the satellites of Jupiter, comprising observations from 1662 to 1802; the second, by Glasenapp, in a Russian thesis,† in which there are discussed the observations of the first satellite of Jupiter from 1848 to 1873. The results of the two determinations are as follow:—

Delambre, $493^{s}\cdot2$; Glasenapp, $500^{s}\cdot84 \pm 1^{s}\cdot02$.

It is quite impossible to judge with certainty just how these two widely discordant values should be combined. The former determination rests on a much greater number of observations than the latter; but it is difficult to form a just estimate of the worth of an average last-century observation of an eclipse of a satellite of Jupiter. And, moreover, astronomers have no means of knowing the process of discussion which led the distinguished French astronomer to his result—which he has adopted in his own tables of the satellites, and which was adopted by Damoiseau in his Tables Écliptiques, published in 1836. The latter determination rests upon a mass of observations of definite excellence, which have been discussed after the modern fashion. I combine the two values giving weight unity to the first, and weight two the second. The adopted value of k is, therefore, $498^{s}\cdot8$, which, combined with the constant of light-velocity just deduced gives the mean radius of the orbit of the earth equal to

149,450,000 kilometers = 92,866,000 miles.

If, now, we combine this result with the value of the equatorial radius of the earth derived by Listing,‡

$$\begin{aligned} a &= 6377^{k}\cdot377 \; [3\cdot8046421] \\ &= 3962^{m}\cdot790 \; [3\cdot5980011] \end{aligned}$$

there results the mean equatorial horizontal parallax of the sun, $8''\cdot802$.

(II.) The velocity of light, the constant of aberration, and appropriate elements of the terrestrial orbit are combined, the equation of connection being,

* Tables Écliptiques des Satellites de Jupiter, par Delambre, Paris, 1819.

† Сравненіе Наблюденій Затмѣній Спутниковъ Юпитера Съ Таблицами Затмѣній и Между Собою . . . С. Глазенапа . . . С.–Петербургъ. . . . 1874.

‡ Neue geometrische und dynamische Constanten des Erdkörpers. Eine Fortsetzung der Untersuchung: über unsere jetzige Kenntniss der Gestalt und Grösse der Erde. Von Johann Benedict Listing. Göttingen, 1878.

$$\frac{\delta g_{,,,}}{\delta t}\frac{a}{\sin\pi} = V\theta\cos\varphi_{,,,}$$

wherein $g_{,,,}$ denotes the mean anomaly of the earth,

$\varphi_{,,,}$, the angle whose sine is the eccentricity of the earth's orbit,

θ, the constant of aberration.

Struve's constant of aberration, 20″·4451, with Listing's value of a, leads to the following results: The mean radius of the orbit of the earth equal to

149,293,000 kilometers = 92,768,000 miles;

and the mean equatorial horizontal parallax of the sun, 8″·811.

It remains to consider the probable variations of the elements of this computation, and the effect of such variations on the derived parallax. The following elements of sensible uncertainty are considered:—

(1.) Uncertainty in the determination of the terrestrial velocity of light. In the process of experimental determinations of the velocity of light, almost no sources of mechanical error have been encountered which cannot, under the most favorable conditions and methods, be reduced to a minimum. What these conditions and methods of experiment are will not now be considered. Let it suffice, for the present, to remark that in approaching the utmost refinement in a determination of such supreme nicety, experimenters are like to be confronted with modifying physical circumstances—which, in all probability, however, need not be considered in connection with any experimental determination of the velocity of light heretofore executed. For the detail of uncertain elements affecting the result of each series of experiments, reference must be had to the individual papers themselves. I am disposed to think that the limit of uncertainty of the velocity of light concluded above may be fairly taken at seventy kilometers.

(2.) Uncertainty in the coefficient of the light-equation of the satellites of Jupiter. The same circumstances, unfavorable in considering the proper combination of the two independent determinations of this constant, hold here. The amount of uncertainty is probably not far from one second of time.

(3.) Uncertainty in the constant of sidereal aberration. I conceive that a variation of 0″·025 in this well determined constant will not be regarded far from the limit of uncertainty. However, this estimate of its variation cannot reasonably be adhered to, except on the supposition that the accepted value of the constant of aberration holds for stars in every part of the celestial sphere,—that is, that the motion of translation of the solar system in luminiferous ether is not sufficiently great to affect the astronomical accuracy of determination of this constant. This question pertains to the astronomy of the future.

(4.) Uncertainty in the relation of the absolute terrestrial velocity to the velocity in space. On this matter, much difference of opinion exists. As the history of the Greenwich water-telescope shows that the constant of aberration is not affected by the passage of the light of the determining star through refracting media, this element of uncertainty exists only in the derivation of the solar parallax through the light-equation of the satellites of Jupiter. The impossibility of an experimental determination of this relation renders the assumption of identity necessary.

(*a.*) Combining the maximum velocity of light with the maximum coefficient in the light-equation, and the minimum velocity with the minimum coefficient, the following relations exist:—

Limiting k	Limiting V	Distance of Sun In kilometers.	Distance of Sun In miles.	Solar Parallax.
$499^s \cdot 3$	299990	149,785,000	93,074,000	$8'' \cdot 782$
$497^s \cdot 3$	299850	149,115,000	92,658,000	$8'' \cdot 822$

(*b.*) Combining the maximum velocity of light with the maximum value of the constant of aberration, and the minimum velocity with the minimum constant, the following relations exist:—

Limiting θ	Limiting V	Distance of Sun In kilometers.	Distance of Sun In miles.	Solar Parallax.
$20'' \cdot 47$	299990	149,510,000	92,903,000	$8'' \cdot 798$
$20'' \cdot 42$	299850	149,076,000	92,633,000	$8'' \cdot 824$

It will be remarked that all these combinations are made in the most unfavorable manner, so as to give the limiting values of the solar parallax with the variations of the elements previously adduced. The probable errors of the intermediate values of the parallax are about one-third these variations.

In conclusion, then, all the experimental determinations of the velocity of light hitherto made give, when combined with astronomical constants, the mean equatorial horizontal parallax of the sun, $8'' \cdot 808 \pm 0'' \cdot 006$.

The corresponding mean radius of the terrestrial orbit is

149,345,000 kilometers = 92,800,000 miles.

Nautical Almanac Office, Washington, Nov. 10, 1879.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Alloys of Gallium with Aluminum.*—Lecoq de Boisbaudran has been studying the alloys which gallium forms with aluminum. If the latter metal be used in large proportion, the two must be heated pretty strongly even to a dull red. The alloys thus obtained remain brilliant, and do not sensibly attract oxygen from the air during their formation. After cooling, they are brittle and but slightly coherent. They decompose cold water, better water at 40°, with elevation of temperature, evolution of hydrogen, and the formation of a chocolate-brown powder which ultimately becomes white flocks of alumina, almost the whole of the gallium being set free in globules apparently free from aluminum. The slow evolution of hydrogen by a solid alloy is considerably quickened by contact with a globule of liquid gallium, owing to electric action. Surfused gallium dissolves aluminum even below 15°, forming very brilliant liquid or pasty alloys, which decompose water with great energy. Ordinarily this decomposition is spontaneous; but sometimes a globule of alloy is inert when thrown into water, while another fragment of the same mass is immediately active, and even renders the first so upon contact with it. On touching the liquid alloy with a fragment of solid gallium, crystals appear which are pure gallium, and which do not act on water. After their removal, the alloy is less active; but if the whole is re-melted by the heat of the hand, the alloy regains its activity.—*C. R.*, lxxxvi, 1240; *Bull. Soc. Ch.*, II, xxxii, 393, Nov., 1879. G. F. B.

2. *On the Volatility of Platinum in Chlorine.*—Several years ago, Seelheim heated a piece of thin platinum foil enclosed in a combustion tube, to full ignition in a slow current of chlorine gas, for twenty-four hours. The tube behind the foil was found covered with brilliant and very perfect crystals of platinum, whose form could be recognized by the unaided eye. To test still further the question of the volatility of platinum in chlorine gas, the author placed some platinous chloride in a small porcelain flask and raised this to a bright red heat in a furnace. After cooling, the flask was carefully broken, and the platinum was found to have sublimed, partly as a network of crystals in the neck, and partly as distinct crystals on the sides and bottom of the flask. The author thinks this experiment of importance in connection with Meyer's dissociation of chlorine; since it is not true, as the paper of Meyer asserts, that nothing but chlorine is volatilized on heating platinous chloride. Indeed the observation of Meyer that the volume of chlorine was one-third greater than at lower temperatures, is completely explained by the equation $Pt_2Cl_4=2Cl_2+Pt_2$=6 volumes, two volumes being platinum vapor. Moreover the problem is still more complicated if, as the experiments of Troost and Hautefeuille have rendered probable, platinous chlo-

ride is itself volatile as such.—*Ber. Berl. Chem. Ges.*, xii, 2066, Nov., 1879. G. F. B.

3. *On the preparation of the Acetic ethers of Polyatomic Alcohols.*—FRANCHIMONT has shown that by making use of the dehydrating powers of zinc chloride, acetyl derivatives of the higher polyatomic alcohols can be obtained with ease. The carbohydrate is warmed with four times its weight of acetic oxide and a small fragment of fused zinc chloride. The acetylization is complete, as experiments with cellulose, mannite, and glycerin have satisfactorily shown.—*Ber. Berl. Chem. Ges.*, xii, 2059, Nov., 1879. G. F. B.

4. *On the Relation between Molecular Refractive Power and Chemical Constitution.*—BRÜHL has continued the investigations of Gladstone and Landolt with reference to the relation between refractive power and chemical constitution, and has obtained some interesting results. The researches of these chemists had shown that the expression $\frac{n-1}{d}$, in which n is the refractive index and d the density, possesses a value for any given substance, which is independent of the temperature. Landolt had multiplied this by the molecular weight, obtaining $P\left(\frac{n-1}{d}\right)$ which he called the molecular refractive power. For feebly refractive media n may represent any definite index, such as, for example, that of H_a, the red line of hydrogen. But in order to compare substances which are highly refractive, as to their refractive power, none of the observed indices will answer, as they are all influenced by dispersion. A refractive index not thus affected would be the index corresponding to a ray of infinitely great wave-length. This Landolt finds as follows: Calling μ_{λ_1} the index for light of wave-length λ_1 and μ_{λ_2} for that of wave-length λ_2, the formula of Cauchy gives, for substances not too highly refractive,

$$\mu_{\lambda_1} = A + \frac{B}{\lambda_1^2} \quad \text{and} \quad \mu_{\lambda_2} = A + \frac{B}{\lambda_2^2}.$$

Hence we have

$$B = \frac{\mu_{\lambda_2} - \mu_{\lambda_1}}{\frac{1}{\lambda_2^2} - \frac{1}{\lambda_1^2}} \quad \text{and} \quad A = \mu_{\lambda_1} - \frac{B}{\lambda_1^2},$$

in which B is the coefficient of dispersion and A the index desired of a ray of infinitely great wave-length. Substituting this last value for n in the formula above, we have the expression $\frac{A-1}{d}$, a constant for the same substance, dependent only upon the chemical character of the body and independent of its density and dispersion, as also of temperature. The product of this by the molecular weight, $P\left(\frac{A-1}{d}\right)$, Brühl calls the molecular refraction. The

densities and the refractive indices were determined at 20°, the former being referred to water at 4° and to a vacuum, the value being indicated by d^{20}_{4} and carried to four decimal places. The indices for obtaining the refraction-coefficient A, were those of H_α and H_γ. In Landolt's investigations, the same molecular refraction was obtained for all isomeric bodies; thus showing that only the number of the atoms and not their arrangement influenced this constant. Hence the atoms have the same refractive power in all their compounds; and by comparing different bodies together the atomic refraction r_A for carbon was given as 4·86, of hydrogen as 1·29 and of oxygen as 2·90. Hence the molecular refraction of $C_xH_yO_z$ would be $R_A=4{\cdot}86x+1{\cdot}29y+2{\cdot}90z$. The author has now shown that the molecular grouping has an essential influence upon the molecular refraction, those atoms which are united directly to each other by more than a single bond, exert a greater influence upon the transmission of light than those singly bound. If R_A be the calculated refraction-equivalent of an unsaturated hydrocarbon, a the influence of a double union, and x the number of pairs of removed hydrogen atoms, the formula for a body represented by $(C_nH_{2n+2})-xH_2$ would be $P\left(\frac{A-1}{d}\right)=R_A+xa$. If y represent the number of pairs of hydrogen atoms removed to form a closed chain, and hence without influence optically, the formula becomes $P\left(\frac{A-1}{d}\right)=R_A+(x-y)a$. For example, in hexylene, one pair of carbon atoms is doubly united. Hence we have $(C_nH_{n+2})-H_2$, and the formula is $P\left(\frac{A-1}{d}\right)=R_A+a$. In diallyl, we have $(C_nH_{2n+2})-2H_2$ and the formula is $P\left(\frac{A-1}{d}\right)=R_A+2a$. In benzene, we have $(C_nH_{2n+2})-4H_2$; but a closed chain exists, with only three double unions; therefore $x-y=4-1=3$ and the formula becomes $P\left(\frac{A-1}{d}\right)=R_A+3a$. Experiment has fully confirmed these conclusions, which have been extended to chlorine, bromine and nitrogen which have atomic refractions of 9·53, 14·75, and 5·35 respectively. The author thus states it:—The molecular refraction of those bodies in which doubly united carbon atoms exist is greater than the value calculated from the sum of the atoms, and the excess is proportional to the number of such dual unions, being two units for one and $2z$ units for z double unions. $M_A=P\left(\frac{A-1}{d^{20}_{4}}\right)=R_A+2z$. But this is simply equivalent to saying that the atomic refraction of carbon is higher when doubly combined. This concedes the variability of atomic refraction, which appears to be the case not only with carbon and oxygen, but also with all polyequivalent elements. The atomic refraction of singly united carbon is 4·86 as above; but that of doubly united carbon is 5·86.—*Ber. Berl. Chem. Ges.*, xii, 2135, Nov., 1879. G. F. B.

5. *A new method for preparing Hydrobromic and Hydriodic acids.*—Since both hydriodic and hydrobromic acids are decomposed by strong sulphuric acid, they cannot be prepared by distilling potassium iodide or bromide with this acid. They are usually prepared by the action of water upon their phosphorus compounds, a process which is tedious and inconvenient. BRUYLANTS proposes a new method for preparing these acids, founded on the fact that bromine and iodine unite at ordinary temperatures with certain organic substances to form compounds which at higher temperatures are decomposed so as to evolve hydrobromic or hydriodic acid. For this purpose he proposes the oil of copaiba, prepared by distilling copaiba balsam with water and drying. The oil boils at 250° to 255°, and can convert three times its weight of iodine or bromine into hydrogen iodide or bromide. It is put in a tubulated retort of 500 cub. cent. capacity furnished with a return condenser, to the end of which is attached a tube leading to a drying cylinder. For 60 grams of the oil, 20 grams of iodine may be used. It is dissolved at a gentle heat, and then the temperature is allowed to rise. A regular evolution of gas soon begins, and when it ceases, the retort is allowed to cool a little, and then more iodine is added, until 150 grams has been used. This quantity of iodine gives 145 to 150 grams hydriodic acid. The oil becomes for the most part solid during the reaction. Bromine is used in the same way, only with more caution. From 60 grams oil and 150 of bromine 142 grams hydrobromic acid were obtained.—*Ber. Berl. Chem. Ges.*, xii, 2059, Nov., 1879. G. F. B.

6. *Thermo-chemistry.*—JULIUS THOMSEN has published (Ber. Berl. Chem. Ges., Nov. 10, 1879), some new and very interesting results from this field of investigation.

(1) The heat of formation of the various anhydrous carbonates regarded as formed from metal, oxygen and carbonic oxide, are given as follows:

Reaction.	Heat Units.	Reaction.	Heat Units.	Reaction.	Heat Units.
K_2+O_2+CO	250,940	$Ba+O_2+CO$	252,770	$Mn+O_2+CO$	180,690
Na_2+O_2+CO	242,490	$Sr+O_2+CO$	251,020	$Cd+O_2+CO$	151,360
Ag_2+O_2+CO	92,770	$Ca+O_2+CO$	240,660	$Pb+O_2+CO$	139,690

If from these numbers we subtract 66,810 units—that is, the heat produced in the reaction $CO+O=CO_2$—we can obtain in each case the heat of formation of the same salts when formed from metal oxygen and carbonic dioxide; that is, in the general reaction $M''+O+CO_2$. If now from these last values we subtract the heat evolved in the oxidation of each metal the result is the heat of formation of the anhydrous salt when produced from the metallic oxide and carbonic dioxide; that is, in the general reaction $M''O+CO_2$. The results thus obtained in a few of the more important anhydrous carbonates are as follows:

Reaction.	Heat Units.	Reaction.	Heat Units.
$BaO+CO_2$	55,580	$PbO+CO_2$	22,580
$SrO+CO_2$	53.230	Ag_2O+CO_2	20,060
$CaO+CO_2$	42,490		

Since the molecule of calcic carbonate weighs 100, it follows that 425 units of heat, in round numbers, are absorbed for every unit of weight of limestone (regarded as pure calcite) burned in a lime kiln. Favre and Silbermann found for the same constant the value 308 units which is ¼ too small. A comparison is made in this paper of the heat of formation of the anhydrous carbonates and sulphates of the same metal, corresponding to the general reactions $R'' + O_2 + CO$ and $R'' + O_2 + SO_2$, from which it appears that the difference is far from constant. In most cases the heat of formation of the sulphate is greater than that of the carbonate, the difference varying from 22,620 heat units in the case of the potassium salts to 3430 units in the case of the silver salts; but in the case of the salts of cadmium and manganese the conditions are reversed, and the heat of formation of the carbonate is greater than that of the sulphate. These facts are thought to indicate that SO_2 and CO, stand in different relations to the molecules of the salts, in which these radicals are supposed to exist as actual atomic groups.

(2) In his previous investigations on the heat of formation of the oxides and acids of nitrogen, Thomsen had left undetermined the heat of formation of NO, which enters as a radical into so many of this class of compounds. The determination of this important value required the construction of a special apparatus, and for this, as well as for other reasons, has been delayed. The result now reached differs greatly from that obtained by Berthelot, and, if sustained, will require a material correction of some of the most important thermo-chemical data. According to Berthelot, $N + O = -43{,}300$ units, while according to Thomsen this value should be $-36{,}395$ units. Thomsen claims that there is a large error in Berthelot's work in consequence of the circumstance that in the process used by the French chemist the quantity estimated was several times greater than the quantity measured, and the quantity measured too small to admit of accurate results under such circumstances. But the details of his own method on which his conclusions are based, are not given in the "Berichte," and he refers to an extended paper in the Festschriften der Universität zu Kopenhagen. How great a change the correction thus introduced makes in some important values calculated from the old data, the following table shows:

	Berthelot.	Thomsen.
$N_2 + O_4$	$-48{,}660$	$-33{,}650$
$N_2 + O_3 + Aq$	$-51{,}800$	$-36{,}430$
$N_2 + O_5 + Aq$	$-14{,}800$	$+180$

For a large number of other thermo-chemical data corrected for the new fundamental value of $N + O$, we must refer to loc. cit., page 2062. J. P. C., JR.

7. *On a New Standard of Light.*—Mr. LOUIS SCHWENDLER presents the advantage of using the incandescence of platinum by means of a constant electric current for a standard of light. In foot-notes he states that this is not a new idea and refers to Dr.

Draper's papers on radiation published in 1844. Mr. Schwendler's lamp differs in no respect from that proposed by Dr. Draper. From his experiments Mr. Schwendler concludes, that to produce the unit of light equal to the light emitted by a standard candle, from 300 to 725 units of current were necessary according to the size of the platinum strip, while with the use of the carbon electric lamp only 10 units of current were necessary. He thereupon states his conviction that "from an engineering point of view, light by *incandescence* can scarcely be expected to compete with light by *disintegration*" (electric arc). He believes that light by *incandescence* is not much cheaper than light by combustion. No reference is made to the late results of Edison on platinum submitted to alternating currents in a partial vacuum.—*Phil. Mag.*, Nov., 1879, p. 393. J. T.

8. *Report on the Electric Light.*—Mr. Louis Schwendler in a report on the expediency of lighting the railroad stations in India by means of the electric light, gives the following results of his measurements. A normal candle, six to the pound, and consuming 120 grains per hour, employs in producing the unit of light, a work of from 610 to 1365 megerga per second. An electrodynamic machine with not more than 0·1 Siemen's units resistance in the circuit, only from 10 to 20 megerga; so that one electric light produced only at one place in the circuit, is 50 times cheaper than the candle. Division of the electric light, on the other hand, Mr. Schwendler finds to be uneconomical. A dynamo-electric machine with the greatest number of divisions of the movable coil, gives the most constant current. The strength of the current increases at first quickly, then is proportional to the velocity of rotation, then increases more slowly. The electromotive force decreases with a constant velocity of rotation more quickly than the entire resistance increases, and the more quickly the smaller the interior resistance of the machine is. When the external resistance is zero, the electromotive force reaches its maximum. The following table represents the conditions in the electric arc: J is the strength of the current in electro-magnetic units (webers), W the resistance in Siemen's units, and E′ the electromotive force in volts.

J	28·81	23·87	16·27	W	0·91	1·72	1·97	E′	2·02	1·91	1·86

A good dynamo-electric machine should make 700 to 750 turns in a minute and afford a current in electro-magnetic units expressed by the formula

$$J = 0{\cdot}3\sqrt{\frac{W' - w'}{R + r}},$$

where W' and w' represent the work respectively during the production of the current and during the running of the machine on an open circuit, and R represents the inner and r the outer resistance. If $J > 20$, the loss of work reaches 12 per cent.—*L. Schwendler*, *Précis of report on Electric light.* London, Waterlow & Sons, 1878. J. T.

9. *Upon the Electro-magnetic rotation of the Plane of Polarization in Gases.*—KUNDT and KÖNTGEN state as the result of their investigation the following:

(1) Atmospheric air, oxygen, nitrogen, carbonic oxide, carbonic acid, illuminating gas, ethyl and marsh gas, indicate a rotation of the plane of polarization in the direction of the positive current.

(2) The amount of this rotation under like conditions is different for the different gases.

They detail the precautions employed in their research, and give the methods at length. It is found that the electro-magnetic rotation is the greater the greater the index of refraction of the gas, although the authors have not been able to determine the exact numerical law which might connect this magnetic effect with this or any physical constants of the gases. They hint at the possibility of determining the amount of rotation of the plane of polarization of air by the magnetism of the earth; and by reference to their table of results, estimate that 253 km. of air in the north-south-direction would experience under the magnetism of the earth a rotation of 1°.— *Wiedemann's Annalen der Physik und Chemie,* No. 10, 1879, p. 278. J. T.

II. GEOLOGY AND NATURAL HISTORY.

1. *A Hudson River fossil plant in the Roofing slate that is associated with chlorite slate and metamorphic limestone in Maryland, adjoining York and Lancaster Counties, Pennsylvania;* by J. P. LESLEY. (From a letter to J. D. Dana, dated Philadelphia, Dec. 6, 1879.)—Professor Lesquereux has just determined *Buthotrephis foliosa* on a slab of roofing slate from the quarries on the Susquehanna River near the Maryland line. This is a most important discovery. Professor Frazer has been studying the roofing slate belt and adjoining chlorites, for several years in connection with his York and Lancaster county work. He never found any traces of organic life, nor could hear of any. But he found several curious forms in the rocks across the state line in Maryland, one of which looked like a flattened *Orthoceras.* Professor James Hall and Mr. Whitfield were disposed to consider them not organic. They have been figured for the American Philosophical Society's Proceedings and for the Reports of the Survey. These are the only fossils ever seen in that region to our knowledge. The slab of *B. foliosa,* is in our museum and will be figured. Professor Frazer received it from a Presbyterian clergyman, professor in Lincoln University, who got it from a miner, with six or seven other larger and finer slabs which he sent to the York Museum, York county, in acknowledgment of aid from the citizens to the University. There seems to be no doubt that the slabs came from the Peachbottom quarries as asserted.

There are two species of *Buthotrephis* known in the Trenton limestone, three in the Hudson River slates, one in the Clinton. One is reported from the Devonian of Russia. Several from the sub-Carboniferous remain unstudied. *B. foliosa* is characteristic

of the Hudson River. It is in the upper part of the Hudson River formation, along the foot of the Kittatinny or Blue or North Mountain on the Lehigh River in Eastern Pennsylvania, that we have our Statington and other roofing slate quarries; and no trap is known in the neighborhood, and no reason can be assigned for excessive metamorphism of structure (not of lithology); but on the Maryland line a trap dike many miles long has been followed by Professor Frazer across Lancaster county, *passing through the* celebrated Gap Nickel mine, to and across the roofing slate belt of Peachbottom. But this belt is a number of miles long, and I can see no important connection between the trap at one end of it and its metamorphism.

Professor Frazer feels sure that the roofing slates are part and parcel of the chlorite slate formation which makes such a show along the river for miles north of the quarries. But the structure is very obscure. To the north of the chlorites, a bold double-crested anticlinal (of Toquan creek) crosses Lancaster and York counties, and is finely exposed upon the two banks of the Susquehanna River, bringing up massive gneisses, etc., evidently belonging to our Philadelphia rocks, to those of the Welsh Mountains west of the Schuylkill River, and to those of the Highlands of New Jersey and New York State.

The chlorite slates are always, with us, seen in juxtaposition with the limestones, which we feel confident are No. II ("Magnesian, Calciferous"); but the structural connection is not quite satisfactory yet. Mr. C. E. Hall is disposed more and more to look upon them as No. III (Hudson River) metamorphosed, all along the Chester county "South valley" hill, and across the Schuylkill into Philadelphia and toward Trenton.

Everything points toward non-conformable basins or outlying patches of metamorphosed Silurians in the heart of our Azoic country of southern Pennsylvania and Maryland, and this discovery of *B. foliosa* leaves very narrow room for further doubt on the subject.

2. *Pennsylvania Second Geological Survey.* Harrisburg, 1879.

(1) *Second Report of Progress in the Laboratory of the Survey at Harrisburg*, by ANDREW S. McCREATH, MM. 438 pp. 8vo.

(2) *The Geology of Lawrence County, and a Special Report on the Condition of the Coal Measures in Western Pennsylvania and Eastern Ohio*, by J. C. WHITE, QQ. 336 pp. 8vo, with a colored geological map of the County and 134 vertical sections.

(3) I. *The Northern Townships of Butler County;* II, *a Special Survey, made in* 1875, *along the Beaver and Shenango Rivers, in Beaver, Lawrence and Mercer Counties*, by H. MARTYN CHANCE. V. 248 pp. 8vo, with four maps, one profile section and 154 vertical sections.

These additions to the series of volumes of Pennsylvania Reports, already numerous, show efficient action in both the head of the Survey and the corps who are at work with him. The first of these Reports, while mostly the work of Mr. McCreath, includes

also the following: Classification of Coals, by P. FRAZER, Jr.; Firebrick tests, by F. PLATT; Notes on dolomitic limestones, by J. P. LESLEY; Utilization of Anthracite slack, by F. PLATT. The analyses of Mr. McCreath are of coals of different coal beds, cokes, iron ores, irons, cinders, clays, fire-bricks, zinc ores, lead ores, limestones, marls, the mineral barite, and other substances, and by their number and character indicate a great amount of excellent work. They are accompanied by descriptions, and often sections, of the beds from which the specimens were taken. The results of tests of Pennsylvania and other coals for weather-waste also are given in tables. The volume is a very important contribution to the practical as well as scientific part of the great subjects of coal and iron.

One of the most important questions before the geologists of Pennsylvania is that with regard to the relation of the rocks of the western margin of the State to those of the adjoining part of Ohio, described by the Ohio geologists. Its settlement is necessary to a correct mapping of the rocks and coal beds of the two States. In Mr. J. C. White's Report, after details on the geology of Lawrence County, in which numerous careful sections are given of the coal beds and associated rocks, the results of a special study on this subject are brought out. The same point, but for a different part of the border region, is illustrated also in the Report of Mr. Chance, who surveyed "the Slippery Rock, Shenango and Beaver River valleys," in 1875, "for the special purpose of connecting the well-known Coal-measures of the Ohio River valley with the then almost unknown or very ill-understood rocks of Northern Butler and Mercer Counties. The same problem has been studied also by Mr. Ashburner, whose results will appear in a Report now in the press. These different observers, according to Professor Lesley, agree closely in their results, and thus the settlement of this question in inter-State geology is essentially accomplished.

3. *Geological Survey of San Salvador.*—The Geological and Economic Survey of San Salvador has been entrusted, by the government of that country, to Mr. W. A. Goodyear, late of San Francisco, and for some years in charge of important work on the Geological Survey of California. Mr. Goodyear sailed about the end of September for his new field of labor.

4. *A Manual of Palæontology, for the use of Students, with a General Introduction on the Principles of Palæontology;* by H. A. NICHOLSON, Professor Nat. Hist. Univ. St. Andrews. 2nd edition, revised and greatly enlarged. 2 vols. 8vo, 1879. Edinburgh and London. (Wm. Blackwood & Sons).—This second edition of Professor Nicholson's Manual of Palæontology is improved in every part, large additions of new matter having been made to its descriptions, and new illustrations introduced after the best style of the engraver's art and largely from drawings on wood by the author. The author's acquaintance with general zoology, and his labors among fossil corals and other inverte-

brate fossils, American as well as British, has well prepared him to make a judiciously arranged and convenient manual for student or instructor; and such is his work. The arrangement is zoological, commencing with the lowest forms, the Protozoans: and in connection with each section the zoological characters and relations, and the stratigraphical position or range are stated. Such general deductions as the science has established are also presented, but without wandering into speculative discussions. The numerous illustrations are well selected for showing structure and generic and family distinctions. Why the author should write *Kainozoic* for *Cœnozoic* or *Cenozoic*, when he uses Eocene, Miocene and Pliocene, and not Eokaine, Miokaine, Pliokaine, is not clear. But this is a point in orthography, and does not diminish the value of the work. The mechanical execution of the work is excellent, quite in harmony with the beauty of the illustrations. All interested in Geology will find Nicholson's Manual of Paleontology a very valuable companion in their studies.

5. *Dana's Manual of Geology.* Third edition. 912 pages. 8vo. Over 1250 figures, with 12 plates and a chart of the world. New York: 1880. (Ivison, Blakeman, Taylor & Co.)—In this new edition of the Manual, the part on Kinds of Rocks has been wholly remodelled; that on Dynamical Geology has been mostly re-written and its pages and illustrations increased in number one-half; and that on Historical Geology, while but partially revised, has received important changes in the pages on the Green Mountains, American fossil Mammals, and the Glacier and Champlain periods of the Quaternary. Through the kindness of Professor Marsh the volume contains also twelve plates: three illustrating the American Jurassic Dinosaurs; two, the two types of toothed birds of the Cretaceous, and giving figures of the complete skeleton; three, the Tertiary Mammals of the Rocky Mountain region; and, one, the relations in size of the brains of Tertiary and Modern Mammals. In addition, brief lists of works and memoirs are added, bringing out the history of opinions in connection with the Dynamics of the Science.

6. *Catalogue of Official Reports upon Geological Surveys of the United States and Territories, and of British North America;* by FREDERICK PRIME, Jr., Assistant Geologist of Pennsylvania. 72 pp. 8vo. From vol. vii, Trans. Amer. Inst. of Mining Engineers, Philadelphia, 1879.—Since Professor Marsh's Catalogue of American Geological Reports was published in this Journal, the number of these Reports has more than doubled, and the science owes much to Professor Prime for the preparation of this new and much improved catalogue. It gives, with the titles, full details as to size, time and place of publication, names of authors of the subordinate reports of a volume, and includes, besides government reports, others of a public character. Copies can be obtained of Professor Prime (907 Walnut street, Philadelphia) in exchange for Geological Reports.

7. *Classification and Description of the American Species of Characeæ;* by B. D. HALSTED.—The earliest paper directly relating to the American *Charæ* appeared in this Journal in 1843, viz: the "*Brief Notice of the Charæ of North America*, by Prof. Alex. Braun, communicated by Dr. Engelmann." Two years later a notice of American *Charæ* appeared in a note to *Plantæ Lindheimeræ*, published in the Boston Journal of Natural History. Since that date we have only scattered references to *Charæ* in local lists and reports of different expeditions, until within the last few years when the attention of our botanists has been more frequently turned to the species of this small but interesting order. The task of determining native species will be much facilitated by two works which have recently appeared. One by Dr. T. F. Allen entitled Characeæ Americanæ, an illustrated work of which two parts have appeared, has already been noticed in this Journal. The other, originally presented as a graduating thesis at Harvard University in May, 1878, by Mr. B. D. Halsted, is now published in part in the Proceedings of the Boston Society of Natural History. There is a short introduction, giving a general account of the structure of the order, followed by detailed descriptions of the eighteen species known to the writer from an examination of the herbaria at Cambridge and a number of private collections. Of the species, eight belong to *Nitella*, one to *Tolypella*, and nine to *Chara*. One new species, *C. Robbinsii*, is described. Among the more interesting species, we may mention *N. gelatinosa* found by Ravenel in the Santee Canal, and the beautiful *C. gymnopus*, var. *elegans*, which was first found by Oakes in Essex County, Massachusetts, where it has recently been rediscovered by Mr. Robinson; and it is now known in other localities. As a whole the paper shows indications of careful study, and there is only one portion which we would criticize. The group of the *Gymnopodæ* including *C. gymnopus* and *C. Robbinsii* should be compared with *C. polyphylla* var. *Michauxii* Braun, which, as it seems to us, may have been confounded with what Mr. Halsted considers to be the typical *C. gymnopus*. It should also be compared with *C. sejuncta* Braun, a species certainly approaching *C. Robbinsii*. The literature of the old *C. Michauxii* and *C. sejuncta* is very obscure, and these two species figure unpleasantly in the foot-notes of inaccessible articles. But we hope to have eventually from Mr. Halsted a further elucidation of the *Gymnopodæ*.

W. G. F.

8. *Untersuchungen über die Zellkerne der Thallophyten*, by Prof. FR. SCHMITZ.—This paper, an extract from the Proceedings of the Niederrheinische Gesellschaft, is a general review of the mode of occurrence of the nucleus in the different groups of Thallophytes. In it the author has embodied his own observations, which have been made principally in reference to Algæ. He shows that the cells of certain genera which were supposed to be without a nucleus really have not one nucleus but a large number of nuclei. He considers that multinuclear cells occur tolerably

frequently among the Thallophytes, especially in species having a siphonous thallus, whether colored (Algæ) or colorless (Fungi). In *Oscillaria*, *Ustilago* and some other genera, however, Professor Schmitz was unable to detect a nucleus. Hæmatoxyline is the reagent advised for bringing out the nuclei in doubtful cases. The article is followed by a note on the *Fructification of the Squamariæ*, which, it appears, have an arrangement of creeping filaments such as have been described by Thuret and Bornet in *Dudresnaya*. W. G. F.

9. *Le Charbon de l'Oignon ordinaire*, by Dr. MAX CORNU.—In the Comptes Rendus of July, Cornu records the appearance in the markets of Paris of the onion-smut, *Urocystis Cepulæ*. The disease which is known to have been common in Connecticut and Massachusetts for a number of years, had not been hitherto observed in France. Dr. Cornu considers *U. Cepulæ* to be distinct from *U. Colchici*. W. G. F.

10. *Entwickelungsgeschichte einiger Rostpilze*, by Dr J. SCHROETER.—This paper, which consists of advanced sheets of an article to appear in the forthcoming number of Cohn's Beiträge zur Biologie der Pflanzen, is replete with interesting facts on the development of different *Uredinei*, for the careful study of which in recent years we are more indebted to Dr. Schroeter than to any other botanist. It includes a synopsis of the European species of *Puccinia* which are found on the *Umbelliferæ*. In reading the paper, one sees at what a complicated condition the study of the *Uredinei* has arrived; and that no one but a specialist can hereafter expect to be able to understand what is written on the different transformations of this most perplexing order of plants. W. G. F.

11. *Botanical Necrology for the year* 1879.

WILLIAM T. FEAY, M.D., died at Savannah, Georgia, on the 22d of May, at the age of not far from 76 years. His remains lie in Laurel Grove Cemetery, under the shadow of the noble live oaks whose boughs are funereally draped with long tufts of *Tillandsia usneoides*, swinging mournfully in the air. This cemetery in the neighborhood of Savannah is associated in the writer's mind with this estimable botanist; for his only visit to it was in Dr. Feay's company one spring morning. We had known him in correspondence, and it was a pleasure to become personally acquainted with this most amiable man. Dr. Feay was one of those botanists who know very much and never publish anything, and who, though living a useful life, wholly fail to play the part to which they are entitled. He was born in South Carolina, studied a while at the University of Georgia, at Athens; then studied medicine at Charleston in his native State, but later turned his mind to scientific studies and to classical scholarship. It is reported that, at a critical period of life, he wasted a considerable patrimony in some excesses; and that when he came to himself and had to live by his own exertions, he chose the life of a school teacher. To this vocation, and to his botanical pursuits as an avocation, he devoted himself entirely for the rest of his life,

and for the best part of it in the city of Savannah, in charge of a private school, living alone and with utmost frugality, devoting all his earnings to the purchase of books and all his spare time to the acquisition of knowledge. During the war of the rebellion he took refuge in Florida, teaching when pupils were to be had, studying plants at all seasons, and making some interesting discoveries. Several of these commemorate his name, among them a *Palafoxia* and a pretty little *Lobelia*.

JACOB BIGELOW, M.D., far the most aged of American botanists, died at Boston on the 10th of January, 1879, at the age of 92. A brief biography was published in a preceding volume of this Journal (xvii, 263), in April last.

JAMES WATSON ROBBINS, M.D., died at Uxbridge, Massachusetts, January 9, 1879, one day before Dr. Bigelow, his only senior among American botanists, as he had reached the age of 77. A biographical notice of him appeared in the Necrology of the preceding year, in February last.

HERMANN ITZIGSOHN, a cryptogamist of considerable repute, whose name is connected with researches on the spermatozoids of the lower tribes of plants, died at Schœneberg, near Berlin, January 4, 1879, at the age of 65.

JOHAN ANGSTRÖM, a distinguished bryologist, of Sweden, died January 19th, at the age of 65.

H. W. BUEK, favorably known for his indexes to DeCandolle's Prodromus, died at Hamburg, February 10th, at the age of 83.

H. G. L. REICHENBACH, the veteran German systematic botanist and in his day a voluminous author, a man greatly respected and honored, died at Dresden, March 17, at the age of 86. The orchidologist of our time, bearing the same name, is the son, now Professor of Botany at Hamburg.

H. R. A. GRISEBACH, Professor at Gœttingen, and one of the most prominent and voluminous systematic botanists of our day, died May 9, in his 66th year. His earliest considerable work was a Monograph of the *Gentianeæ*, in 1839. His most important one, a comprehensive treatise on the Vegetation of the Earth, was published in 1872; his latest, Symbolæ ad Floram Argentinam, appeared about the time of his unexpected decease. He is well known in this country for his elaboration of the extensive collections of Charles Wright in Cuba, as well as for his Flora of the British West Indies, one of the earlier of the English Colonial floras.

THILO IRMISCH, an acute morphologist, author of many valuable papers, especially on the subterranean parts of plants, died at Sondershausen, Germany, April 28, at the age of 64.

EDOUARD SPACH, native of Strasburg, for very many years the keeper of the Herbarium at the Paris Museum, Jardin des Plantes, in the earlier portion of his scientific life a voluminous author, an acute systematic botanist, a worthy representative of the school which is disposed to multiply genera upon single characters, died May 17, at the age of 78. He had been for some time superannuated.

KARL KOCH, the prince of horticultural botanists and a most learned dendrologist, born at Weimar in 1809, explorer of Asia Minor and the Caucasus in especial reference to the origin or nativity of the long-cultivated plants of the Old World, died at Berlin, May 25, in the 70th year of his age.

DAVID MOORE, Director for the last forty years of the Glasnevin Botanic Gardens, Dublin, which he kept in unrivalled perfection, author in part of the Cybele Hibernica, of a synopsis of Irish Mosses and a Report on the Irish Hepaticæ, died June 9, at the age of 72.

EDWARD FENZL, who forty years ago was the assistant of Endlicher in the Vienna Imperial Herbarium, since Endlicher's death in 1849 the Professor of Botany and Director of the Botanic Garden at Vienna down to the year 1878, whose earlier studies were directed to the *Alsineæ* and their allies, and who published various memoirs of critical value, died September 29th, in the 72d year of his age.

JOHN MIERS, the Nestor of English botanists, died at his residence in London, October 17th, at the great age of 90. He went to South America many years ago as a mining engineer, there took up with ardor the study of botany in which he has so long persevered, made a vast number of drawings and sketches, for which he had a great facility, and in about 1840 he began the long series of his papers in systematic botany, monographical and critical, of which over fifty are enumerated in the Royal Society's Catalogue of Scientific Papers coming down to the year 1863, but whose issue continued down nearly to the last year of his remarkable life. Original in his treatment, and ready to grapple with recondite questions of affinity, in which it is not always easy to control plausible inferences by decisive tests or by intuitive judgment, the value of Mr. Miers' work must be various, and that of much of it not yet determinable. Some of it is doubtless over-ingenious, and too great trust may have been placed upon drawings prepared long before their use. But the indomitable spirit of the man, and his guileless amiability were equally and wholly admirable. A. G.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Geological Survey of the Public Domain.*—In the Congressional discussion, referred to in our former historical notice of the Department for the Geological Surveys of the National Domain, page 492 of the preceding volume, the question of an extension of the Survey into "all the States" was, as the writer finds, alluded to in its various bearings, though briefly. The form of the amendment to the bill, as it was finally passed by the House, is, in full, as follows:

Provided, That this officer shall have the direction of the Geological Survey, and the classification of the public lands and examination of the geological structure, mineral resources, and

products of the National Domain, and he may extend his examination into the States, not to interfere, however, with any Geological Survey now being made by the States."*

The vote for the amendment stood—yeas, 92, nays 53, 141 *not voting.* It thus appears that the important measure, sprung upon the House in its closing hours, unknown to, and unconsidered by, the country, *had only ninety-two votes in its favor.*

In order that the exact views of those who advocated the bill may be understood, we make a few citations from the remarks in the discussion. Mr. Atkins, its most urgent advocate, said: "Tennessee has a large deposit of coal and iron, and would be glad to have accurate information as to it." "The object that I had in offering this joint resolution was simply to enable the Geological Director to make in his next report a practical presentation of the mineral resources of the States of the Union, so far as they relate to coal and iron." "The object is to make surveys of the mineral deposits in all the States." Mr. Wilson, of West Virginia, said: "The vast mineral wealth locked up in our mountains should be developed." Mr. Haskell said "Congress does not possess the power to oust the State surveys from their work under the State laws, and this is simply to give free and full power and opportunity to give us what we need—a Geological Survey of the United States." On the other hand, Mr. Reagan, of Texas, said "I shall vote against this bill, either with the amendment or without the amendment, because I do not believe the Constitution enables me to pass such a law. We, day by day, and step by step, in advance of them [our predecessors], proceed without the authority of the Constitution in creating new sources of expenditure, and entailing new burdens on the people."

Thus the investigation of ore deposits is a chief end in view —ore deposits which belong to private individuals, not to the country. It is asked that the ore beds in Tennessee should be investigated by a United States agent, with the general government to meet the expense. The mineral resources of the country are to be investigated, not by each State for the benefit of the State and its citizens, as is done for other resources, but by the General Government. Tennessee has an able geological investigator in her own State Geologist, Professor James M. Safford, who has already studied the coal and iron deposits of Tennessee; and if appointed to the work by the State, or by any interested party, he would make as thorough and satisfactory a report on the subject as any one that is or may be connected with the Geological Survey Department under the United States, and for a small part of the sum that the general government would be likely to pay. Pennsylvania has able geologists, now at work, in Professor Lesley and the men who are associated with him in the geological survey of the State; and Professor Lesley has given more time to the subjects from a geological and geologico-economical point of view

* This and the following quotations are from the Congressional Record for June 29.

than any other person in the country. So other States have their geologists, whose labors have been much among coal and iron deposits, and who are ready to carry on any further investigations that may be made. A special agent at Washington is not wanted, unless it be that the United States Treasury is, through Congress, a more accessible source of funds for surveys than the State Treasuries. The idea that here is an open door for the supplies needed for new geological surveys would be pretty sure to give such a scheme favor among geologists.

The following are points deserving careful consideration before the amendment is passed.

(1.) Its passage will put an end to all State Geological Surveys; for, by it, the General Government appoints a Director for such surveys, and gives, thereby, an implied pledge that it will supply the funds required.

(2.) Its provisions embrace not only paleontological and geological surveys for the whole country, and surveys of mineral deposits, but surveys of the lands of the country at large with reference to Agricultural resources, and to all other points on which the value of the Public lands depend. And it might include surveys with reference to water-power along all streams with the same propriety, as these are resources of the highest importance.

(3.) All the States may go to Congress for appropriations for these various purposes, if they are granted to one.

(4.) Nearly all the States have had their Geological Surveys and have published volumes of Reports containing their results with regard to the rocks, fossils, ore beds and all mineral resources. More detailed and complete surveys could, however, in all cases be made. But it would be vastly better, that mensuration surveys should first have been carefully made, as the writer has already urged. And with respect to the ore-deposits, these are now so well known through the surveys that have been made, that what remains, even in Tennessee, may well be left to private enterprise. There is no real need for help from the General Government.

(5.) The development of the *resources* of the States being assumed at Washington, State rights and State duties would thereby be absorbed by the Central Government; and this centralization is opposed to the spirit if not the letter of the Constitution of the United States.

(6.) The expense of carrying out the provisions of the amended bill would be enormous. For the region to be covered by the detailed surveys is the whole country, and the time its accomplishment would demand would reach far into the indefinite future.

As the history of the Department of Geological Surveys is of great national interest, we publish here a copy of the estimates which Mr. King has submitted to Congress for the work of the Geological Survey Department, during the next fiscal year ending June 30, 1881.

Geological survey of iron and coal resources of public domain	$30,000.00
Extending observations on coal and iron into old States	20,000.00
Survey of agricultural geology on public lands of Mississippi Basin	25,000.00
Geological survey of gold and silver in Division of Rocky Mountains	35,000.00
Geological survey of gold and silver in Division of Great Basin	35,000.00
Survey of geological structure of public lands in Mississippi Basin	25,000.00
Survey of geological structure and classification of public lands of Rocky Mountains	30,000.00
Survey of geological structure and classification of public lands in Colorado Basin	40,000.00
Survey of geological structure and classification of public lands in Great Basin	30,000.00
Survey of geological structure and classification of public lands in Pacific	25,000.00
	$330,000.00

Thus Mr. King assumes that the proposed amendment is as good as passed, and makes his call for 330,000 dollars for his first year's expenses. The proposition for "the States" is not very large; it is a beginning. J. D. DANA.

2. *A Handbook of Double Stars, with a Catalogue of Twelve Hundred Double Stars, and extensive Lists of Measures. With additional Notes, bringing the Measures up to* 1879. For the use of Amateurs. By EDWD. CROSSLEY, F.R.A.S., JOSEPH GLEDHILL, F.R.A.S., and JAMES M. WILSON, M.A., F.R.A.S. London, 1879. (Macmillan & Co.)—No work on this subject has of late years appeared which will prove of such general acceptance to all classes of observers as this excellent handbook. Only those who have experienced delay and vexation from inability to procure the published measures of stars can fully appreciate the patient labor which the compilers have bestowed upon this volume; and though it is modestly dedicated to the use of amateurs, it is one of those books which the professional astronomer will find convenient for ready reference in the observing room.

The work (which is gotten up in excellent style, typographically), is divided into four parts: "the first part, historical and descriptive of instruments and methods; the second is mathematical; the third part contains lists of measures of the most interesting double and multiple stars, with historical notes on those which are of special interest; the fourth part is bibliographical." There is so much that is thoroughly good in this work that it seems captious to suggest any omissions: yet it is very natural for an American to ask, why is "Chauvenet's Astronomy" so persistently ignored by English equatorial observers? The book is mentioned, certainly, but his elegant methods of reducing micrometer observations are not given; nor is there any reference to his exhaustive discussion of the errors to which the equatorial is liable. The slipping piece to the micrometer box, though originally we think an English invention, is not mentioned, though it is of great value where the clock-work is not in nice adjustment and the observer

wishes to use but one micrometer-screw. Gauss's modification of Bessel's method for determining the focal length of the object-glass should have been given, because it is one of the very best methods of determining the value of the revolution of the micrometer-screw; and most observers would have liked to have something about the different eye-pieces, achromatic and otherwise, made by Steinheil, Clark and others.

The working out of orbits by both the graphical and analytical methods is an excellent feature, and it would be difficult to improve on the arrangement of the catalogue and measures. L. W.

3. *Double Star Observations made in* 1877–8 *at Chicago with the* 18½*-inch Refractor of the Dearborn Observatory, comprising*, I, *a Catalogue of* 251 *new double stars with measures, and*, II, *Micrometrical measures of* 500 *double stars;* by S. W. BURNHAM, M.A. From the Memoirs of the Royal Astronomical Society, vol. xliv.—Mr. Burnham's Memoir was received too late for a notice. It bears testimony to his ability, precision and energy as an astronomical observer. His observations make an important part of the Handbook of Double Stars, just noticed.

4. *Solar Light and Heat, the Source and the Supply: Gravitation: with explanations of Planetary and Molecular Forces;* by ZACHARIAH ALLEN, LL.D. 241 pp. 8vo. New York, 1879. (Appleton & Co.)—This is a sequel to the work published by the author in 1851, The Philosophy of the Mechanics of Nature, etc. The idea of the author is, that the revolving planets in passing through the universally diffused electric ethers generate by their motion the moving force which comes to us as light and heat. It is hardly to be expected that his views will be accepted by physicists.

OBITUARY.

Professor B. F. MUDGE.—Professor Mudge died at his residence, in Manhattan, Kansas, suddenly, on the 21st of November, of apoplexy. Professor Mudge was the State Geologist of Kansas. Only a few months since—last September—his Report on the Geology of Kansas was noticed in this Journal. Professor Mudge was a man of great industry in his favorite science, and made large collections of fossils, which were, however, sent to others to describe. Lesquereux was indebted to him for collections of Cretaceous plants from the Dakota group in Kansas, which make a considerable part of his report, and Professor Marsh for specimens of Cretaceous vertebrates. Professor Mudge thus contributed largely to the progress of American Paleontology, although not himself describing the species he collected. In 1866, a paper of his appeared in this Journal, on fossil footprints in the Carboniferous of Kansas, and another, in 1868, on a meteorite which passed over the State.

JOHN JOHNSTON, since 1835 Professor of Chemistry at Wesleyan University, Middletown, Conn., and for some years past relieved as Emeritus Professor, died at the residence of his son at Clifton, Staten Island, December 1st, 1879, in his 74th year. He was a conscientious and successful teacher of science, and papers by him on mineralogical and physical subjects will be found in the earlier volumes of this Journal.

APPENDIX.

ART. XI.—*New Characters of Mosasauroid Reptiles;* by Professor O. C. MARSH. With Plate I.

THE Mosasauroid reptiles are so rare in Europe that the type specimen described by Cuvier still remains the most perfect yet discovered there, and the only one from which important characters have been made out. In this country, however, this group attained a marvelous development, and was represented by several families, and numerous genera and species. The abundance of specimens is perhaps best illustrated by the fact that the Museum of Yale College contains remains of not less than 1,400 distinct individuals. In not a few of these, the skeleton is nearly if not quite complete, so that every part of its structure can be determined with almost absolute certainty. From this store of material, I have already made out various characters of these reptiles,* and in the present communication several others are recorded, which have escaped the attention of previous observers. The subject is by no means exhausted.

THE STERNUM.

The absence of a sternum has been asserted by Cope to be one of the important characters of the Mosasauroid reptiles,† and this statement has been accepted by some authors. Several specimens, however, in the Yale Museum, one of which is figured in Plate I, figure 1, prove the contrary, and indicate the presence of a sternum in the entire group.

The most perfect specimens of the Mosasauroid sternum preserved pertain to the genus *Edestosaurus*, and are of the true Lacertian type. The sternum in this genus is narrow, and elongate in form, and nearly or quite symmetrical, as shown in Plate I, figure 1. It is thin, slightly concave above, and convex below. Its antero-lateral margins are short and rounded, and have distinct grooves for the coracoids. The costal margins are much longer, and converge posteriorly. Each has facets for five sternal ribs, and, behind these, false ribs were supported by a partially ossified pedicle, which joined the end of the sternum. The ossification of the sternum was by endostosis.

* This Journal, vol. i, p. 447, 1871, vol. iii, p. 448, 1872.

† Vertebrata of the Cretaceous, p. 114, 1875. Also, Bulletin of Survey of Territories, p. 309, 1878.

In the other genera of Mosasauroid reptiles, the sternum has not yet been found so well preserved as in *Edestosaurus*, but there can be no reasonable doubt of its presence. In *Holosaurus* there appears to have been a partially ossified mesosternum.

The Fore-limbs.

In Plate I, figure 1, the entire pectoral arch and paddles of *Edestosaurus* are represented, essentially as found in the matrix. Hitherto, the limbs of this genus have been only partially known. The general structure of the paddle is Cetacean in type. The humerus is very short, and the radius is larger than the ulna. There are seven distinct carpal bones. The outer one of the proximal series, which probably represents the pisiform, does not assist in the support of any metacarpal. The digits are five in number, of moderate length, and much expanded. The writer has already determined and figured the fore-limb in *Lestosaurus*,* and the entire arch and paddles are here given for comparison. In this genus, there are but four carpal bones, all grouped together on the ulnar side. There are five digits, longer, and less expanded than in *Edestosaurus*.

In *Tylosaurus*, the coracoid has no emargination. The humerus, fore-arm, and entire paddle is much longer than in the above genera, and the digits were less expanded. The number of phalanges was much greater, especially in digits IV and V.

The Hind-limbs.

Since the writer discovered the posterior limbs in several genera of the Mosasauroids, and figured the pelvic arches, little has been added to the subject. In Plate I, figure 3, the complete pelvic arch and hind paddles of *Lestosaurus* are represented, the latter nearly in the position in which they were found. They are considerably smaller than the fore-paddles, but very similar in general form and proportions. The femur is more slender than the humerus, and there are but three tarsal bones, all on the outer or fibular side. There are five well developed digits, and the number and position of the phalanges are shown in the figure.

In *Tylosaurus* the hind-paddles are smaller than those in front, but their structure is very similar. All the genera of the *Mosasauroid* group have a well developed pelvic arch, and functional posterior limbs.

The Hyoid Bones.

No hyoid bones have hitherto been observed in this group, but they exist in *Tylosaurus* and *Lestosaurus*, and doubtless in all the genera. A pair of these bones was found beneath a

* This Journal, vol. iii, Plate X.

skull of *Tylosaurus micromus* Marsh, and one of the specimens is represented in the figures below, which give its main characters. The upper end is obliquely truncated, and occupied by a rugose, concave face (*a*) resembling an imperfect suture. The shaft is slender, and somewhat curved. The lower end is expanded, and has two distinct facets on the outer and inner angles (*b* and *c*), where it was attached to other bones. In *Lestosaurus* there are hyoid bones very similar in form to those here described.

1.

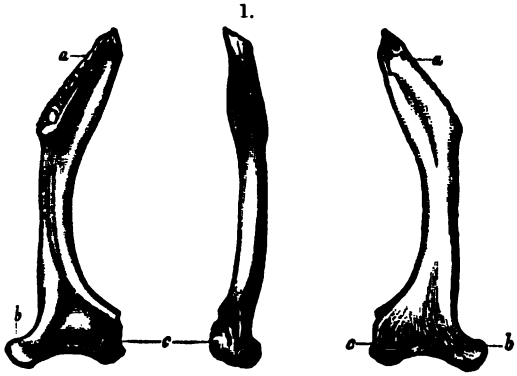


Figure 1.—Three views of a hyoid bone of *Tylosaurus micromus*, Marsh; one-half natural size.

In *Lestosaurus* and *Tylosaurus*, there is apparently another pair of hyoid bones, more slender than the one here figured.

THE SCLEROTIC PLATES.

In the genera *Lestosaurus* and *Tylosaurus*, the orbit was protected by a ring of osseous plates, somewhat like those in *Ichthyosaurus*, and a few recent birds. This ring was composed of only a single row of plates, which in position overlapped each other. These plates are subrectangular in shape, longer than wide, and their general features are shown in the figures given below. The lateral edges are bevelled so as to form a strong union. This bevelling is not uniform, but is so situated as to produce three kinds of plates. Some of these are shaped like those in several modern birds, where the opposite lateral edges are bevelled, one above and the other below (figure 2*a*), forming when united a regular imbricated ring. Besides this variety, however, two other kinds are found in Mosasauroids, namely: one with both lateral edges bevelled below (figure 3), and the other with these margins bevelled above (figure 4). These three kinds occur in the same orbit. All of these plates are somewhat curved, with the concavity external. The outer margins are thickened, and the inner thin and sharp. The

subrectangular shape of all the plates shows that when in position, the outer and inner diameters of the sclerotic ring were not widely different.

Figures 2, 3, and 4.—Sclerotic plates of *Lestosaurus simus*, Marsh; natural size, external view.

The sclerotic plates of the Mosasauroids may be distinguished from the dermal scutes on the head and body by their peculiar shape, and much larger size. The latter, so far as known, are more rhombic in form, but their variations on different parts of the body, and in different species, remain to be determined.

The Transverse Bone.

The element in the reptilian skull which Cuvier called the transverse bone, and Owen, the ectopterygoid, has not been observed hitherto in the Mosasauroids, but it is present in *Tylosaurus*, *Lestosaurus*, and *Edestosaurus*. In the first of these genera, it is an L-shaped bone, thin and somewhat twisted. One ramus unites by suture with the corresponding process of the pterygoid, and the other extends forward, nearly at a right angle, to join the posterior end of the maxillary.

The Pterygoid Bones.

There has been some uncertainty in regard to the bones called pterygoids by Cuvier, but the accuracy of his determination can no longer be fairly questioned. Various specimens in the Yale Museum show conclusively that the dentigerous bones of the palate in various genera of Mosasauroids were attached posteriorly to the quadrates by ligament; to the basipterygoid processes in the same way; to the maxillaries by the intervention of a distinct transverse bone; and to the true palatines by squamous suture. Cope has called these dentigerous bones "*palatines*," and stated that they were separated from the quadrates by intervening bones;* but on both points he was in error. The true palatines are small edentulous bones, in front and outside of the pterygoids. They

* Vertebrata of the Cretaceous, p. 118.

›arate the latter from the slender, distinct vomers. In the nus *Tylosaurus*, the posterior ends of the pterygoids form a stinct head. In *Lestosaurus* and *Holosaurus*, this extremity is ›ad and thin. In none of these genera were the pterygoids ited by suture on the median line, but were more or less dely separated.

The new characters above presented are all Lacertilian, rather an Ophidian. The important characters of the Mosasauroids w known indicate that they form a suborder of the Lacertilia, iich should be called *Mosasauria.*

Holosaurus abruptus, gen. et sp. nov.

The type specimen on which the present genus is based is e of the most complete skeletons of the Mosasauroid reptiles t discovered. This genus is most nearly related to *Lestourus*, and agrees with it in the form and general characters of e skull. It may be readily distinguished by the coracoid, iich is entirely without emarginations, as well as by other ints of difference. From *Tylosaurus* it is separated widely the premaxillaries, mandibles, and the palatines.

The present species was one of the shortest in proportion to bulk hitherto described, the skull and tail being both ruptly terminated. The entire length was about twenty et. There are 98 vertebræ preserved between the skull and point in the tail where the caudals have a diameter of one ch. Many of these vertebræ are in position. The caudals eserved all had articulated chevrons.

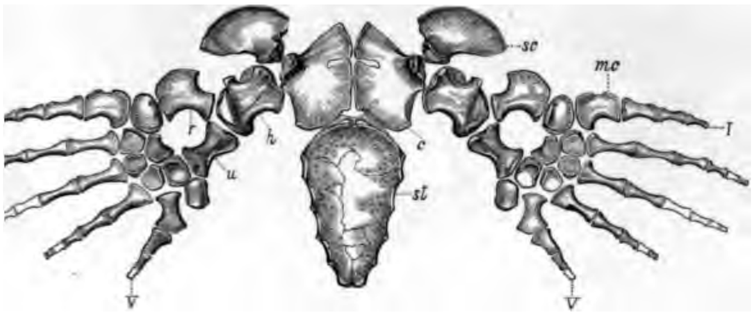
Some of the dimensions of the present specimen are as llows:

Length of entire lower jaw (two feet)	610·mm
Length of dentary bone, on lower border	342·
Length of twelfth vertebra	71·
Transverse diameter of ball	50·
Length of twentieth vertebra	85·
Length of humerus	146·
Width of distal end	136·
Length of radius	102·
Length of ulna	88·
Length of femur	141·
Width of distal end	85·
Length of fibula	117·
Width of distal end	100·
Length of tibia	99·
Width of distal end	76·

This specimen was found in the yellow Cretaceous chalk of ansas, by Mr. S. W. Williston, of the Yale Museum.

Yale College, New Haven, Dec. 20th, 1879.

1.



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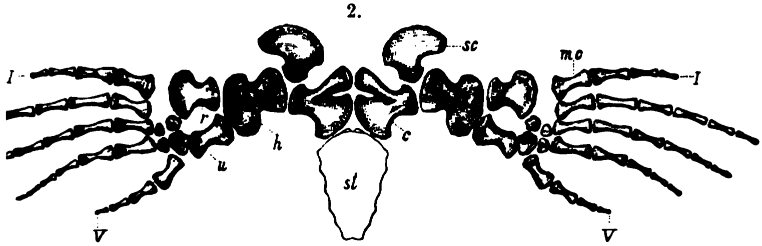

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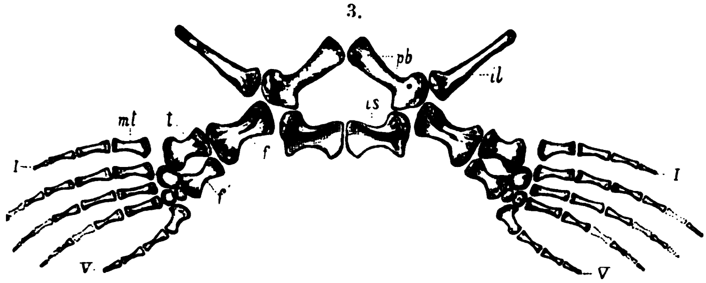


e 1.—Scapular arch, sternum, and fore limbs of *Edestosaurus dispar*, Marsh; seen rom above, one-fifth natural size; *sc.* scapula; *c.* coracoid; *st.* sternum; . humerus; *r.* radius; *u.* ulna; *mc.* metacarpal; *I.* first digit; *V.* fifth digit.

e 2.—Scapular arch and fore limbs of *Lestosaurus simus*, Marsh; seen from elow, one-sixteenth natural size. Letters as in figure 1. Outline of sternum from *'destosaurus*.

: 3.—Pelvic arch and hind limbs of *Lestosaurus simus;* seen from below, one velfth natural size; *il.* ilium; *pb.* pubis; *is.* ischium; *f.* femur; *t.* tibia; *f'.* fibula; *t.* metatarsal.

ıddles are represented as horizontal, and the bones of the arches are somewhat splaced to bring them into the same plane.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XII.—*Contributions to Meteorology, being results derived from an examination of the observations of the United States Signal Service and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Twelfth paper, with three plates.

[Read before the National Academy of Sciences, New York, Oct. 28, 1879.]

Mean pressure of the Atmosphere over the United States at different seasons of the year.

DURING the last three or four years I have devoted much time to the study of atmospheric disturbances in their progress across the Rocky Mountains. This work has been attended with serious difficulties, a part of which have resulted from the mode in which the barometric observations at the mountain stations of the United States Signal Service are reduced to the level of the sea. The method of reduction consists in adding a constant quantity to the observations at each station; and the same constant is adhered to throughout the entire year. That this mode of reduction is erroneous appears from a comparison of the observations on Mt. Washington with the observations at neighboring stations near the level of the sea. In the following table, column 2d shows the mean height of the barometer on Mt. Washington (reduced to sea-level by the Signal Service method) for each month of the year according to the observations of six years (1871–7). Column 3d shows the mean of the observations at Burlington, Vt., and Portland, Me. (also reduced to sea-level) for the same period; and column 4th

shows the differences between the numbers in the two preceding columns.

	Mt. W.	Bur. & Port.	Diff.		Mt. W.	Bur. & Port.	Diff.
January	29·724	30·054	−0·330	July	30·225	29·929	+0·296
February	·693	29·984	− ·291	August	·282	30·008	+ ·274
March	·715	·927	− ·212	September	·165	·003	+ ·162
April	·873	·930	− ·057	October	·015	29·996	+ ·019
May	30·039	·935	+ ·104	November	29·836	·979	− ·143
June	·153	·926	+ ·227	December	·695	30·004	− ·309

We thus find that by employing a constant reduction to sea-level for all months of the year, the pressure for Mt. Washington in January is made 0·33 inch too small; and the pressure in July is made 0·296 inch too great.

A similar error must exist in the reduction of the observations at the Rocky Mountain stations, but it is more difficult to determine its exact amount, because the nearest stations of comparison which are situated less than 1,000 feet above the level of the sea, are distant over 500 miles. Under these circumstances I have endeavored to reduce the observations at each of the mountain stations to the level of the sea, for each month of the year, independently. The chief difficulty in making this reduction arises from the uncertainty as to what should be regarded as the temperature of the point situated at the level of the sea and directly under a given mountain station. The following is the method which I attempted to employ. I determined for each month the mean temperature of a point on the Pacific coast, and also the temperature of a point in the Mississippi Valley, each having the same latitude as the given station. Between the two temperatures thus determined, I interpolated a value corresponding to the differences of longitude between the given station and the two points above named.

The following table shows the required data for the month of January and the results of the computation for each of the stations (except Mt. Washington and Pike's Peak) for which the reduction to sea-level by the Signal Service is made by the addition of a constant quantity.

Stations.	Lat.	Long.	Elev., feet.	Temperature.		Reduc. to s. lev.		Mean barom.	
				Station.	Base.	Sig. S. inch.	Comp. inch.	Sig. S. inch.	Comp. inch.
	° ′	° ′		°	°				
Santa Fé	35 41	106 10	6862	29·76	46·32	6·54	6·81	29·733	30·00
Denver	39 45	105 4	5162	26·14	36·23	5·22	5·37	29·944	30·09
Cheyenne	41 12	104 42	6057	23·26	31·80	5·94	6·26	29·850	30·17
Salt Lake C.	41 10	112 0	4362	29·23	37·62	4·33	4·61	29·959	30·24
Corinne	41 30	112 18	4249	28·30	37·29	4·25	4·53	30·115	30·39
Virginia C.	45 20	112 3	5480	16·82	27·21	5·48	5·76	29·646	29·93
Fort Benton	47 52	110 40	2674	8·28	19·20	2·90	3·04	30·008	30·15

Columns 2 and 3 show the latitude and longitude of the stations named in column 1; column 4th shows the elevation of the stations above sea-level as assumed by the Signal Service; column 5th shows the mean temperature of each station for the month of January according to the observations of five years; column 6th shows the temperature at the level of the sea directly under each station, estimated in the manner already described; column 7th shows the reduction to sea-level adopted by the Signal Service; column 8th shows the reduction to sea-level computed by Dunwoody's Tables contained in the Annual Report of the Signal Service for 1876, pp. 354–360; column 9th shows the mean pressure for each station as deduced from the Signal Service observations, and column 10th shows the mean pressures corrected by the reductions given in column 8th.

If now we attempt to represent by isobaric lines all the observations at the Signal Service stations for the month of January (employing for the Mountain stations the values given in column 10 of the preceding table), we find that nearly all the observations can be well represented by curve lines which have a tolerably symmetrical form. There are only four cases in which the discrepancies amount to as much as 0·05 inch, viz: Virginia City, Santa Fé, North Platte and Dodge City.

The result above found for Virginia City indicates a probable error in the assumed elevation of that station. According to Hayden, the height of Virginia City is 5,824 feet; according to DeLacy it is 5,778 feet; and according to the Signal Service it is 5,480 feet. The mean of these three determinations is 5,694 feet. Assuming this to be the true elevation, the corrected pressure becomes 30·15, which accords pretty well with the observations at the other stations.

According to Wheeler the height of Santa Fé is 7,047 feet, and according to the Signal Service 6,862 feet. Assuming the true elevation to be 7,000 feet, the corrected pressure becomes 30·14, which accords tolerably well with the observations at the other stations.

The results at North Platte and Dodge City appear to be about 0·25 inch too small. These discrepancies cannot reasonably be ascribed to error in the assumed elevations, but they are apparently due to an erroneous mode of reducing the observations to sea-level. If the observations at these stations as published in the International Bulletin are reduced to sea-level by Dunwoody's Tables, the results will be found to agree pretty well with those at the neighboring stations. I then drew the isobars which best represent all the Signal Service observations for the month of January, including the four stations above named, with the corrections which have been indicated. These curves exhibit an area of high pressure for the central part of

the American Continent somewhat similar to that which prevails in winter over nearly the whole of Asia, but much inferior in amount. This area is however apparently divided into three subordinate areas of maximum pressure, one having its center near Salt Lake City; another near Yankton, and a third near Atlanta in Georgia.

I next made a similar comparison of the barometric observations for the month of July, and the results for the mountain stations are exhibited in the following table.

Stations.	Temperature.		Reduc. to s. lev.		Mean barom.	
	Station.	Base.	Sig. S. inch.	Comp. inch.	Sig. S. inch.	Comp. inch.
Santa Fé	69°·13	70°·31	6·54	6·35	29·898	29·71
Denver	73·00	70·24	5·22	4·92	30·105	29·80
Cheyenne	69·45	70·34	5·94	5·71	30·098	29·87
Salt Lake City	76·60	67·24	4·33	4·22	29·978	29·87
Corinne	76·20	67·19	4·25	4·13	30·028	29·91
Virginia City	65·33	69·67	5·48	5·20	29·822	29·54
Fort Benton	73·47	65·33	2·90	2·66	29·965	29·72

Column 2d shows the mean temperature of each station for the month of July according to the observations of five years; column 3d shows the temperature at the level of the sea directly under each station, estimated in the manner before indicated; column 4th shows the reduction to sea-level adopted by the Signal Service; column 5th shows the reduction to sea-level computed by Dunwoody's Tables; column 6th shows the mean pressure for each station according to the Signal Service observations; and column 7th shows the mean pressure corrected by the reduction given in column 5th.

It will be noticed that in four of the seven cases in the preceding table the temperatures in column 2d are greater than in column 3d, and the average of the temperatures in column 2d is considerably greater than in column 3d. This may be regarded as demonstrating that I have adopted a very absurd mode of deducing the temperature at the level of the sea. But it may be replied that the summer temperature in the Salt Lake Basin is higher than it is upon the same parallel on the Atlantic coast or the Mississippi river, and very much higher than it is on the Pacific coast. If we assume a decrease of temperature of one degree for each 300 feet elevation, we shall have a mean temperature of 91° for July at the level of the sea under Salt Lake City, which certainly is not the temperature which would prevail there if the mountains were removed. If we assume the temperature at the sea-level to be the same as that actually observed at Salt Lake City, the reduction of the barometer to sea-level will be 0·04 inch less

than that given in the above table, which change would not materially affect the conclusions which I have drawn from the observations.

If now we attempt to represent by isobaric lines all the observations at the Signal Service stations for the month of July (employing for the mountain stations the values given in the last column of the preceding table), we find that all the observations are pretty well represented except those at the four stations above named, viz: Virginia City, Santa Fé, North Platte and Dodge City.

If we assume the height of Virginia City above sea-level to be 5,694 feet, the corrected pressure becomes 29·74, which accords very well with the observations at the other stations. If we assume the height of Santa Fé above sea-level to be 7,000 feet, the corrected pressure becomes 29·84, which also accords very well with the other observations.

The results at North Platte and Dodge City appear to be about 0·30 inch too small, which is apparently due to an erroneous mode of reducing the observations to sea-level, as intimated on page 91.

I then drew the isobars which best represent all the Signal Service observations for the month of July, including the four stations above named with the corrections which have been indicated. These curves exhibit an area of low pressure for the central part of the American continent similar to that which prevails in summer over nearly the whole of Asia, but far inferior in amount.

The preceding part of this article was written before I had seen a copy of the Annual Report of the United States Signal Service for 1878. This report contains (pp. 418–19) the mean height of the barometer for each station from the opening of the station to June 30, 1877, the observations being corrected for temperature and instrumental error only. As soon as I saw this table I decided to substitute it for the table which I had previously prepared, and proceeded to reduce all the observations to the level of the sea in the following manner. The heights of the stations were assumed as given in the Signal Service Report for 1878 with the exception of Virginia City and Santa Fé. The height of the former was assumed to be 5,694 feet, and the latter 7,000 feet, for the reasons stated on page 91. For the month of July the temperature at sea-level was assumed to be the same as at the station. The same rule was adopted for January for stations whose altitude is less than 1,200 feet. For stations whose altitude is greater than 1,200 feet, the temperature at sea-level was determined in the manner described on page 90. The reduction to sea-level was then computed from the data thus furnished by using Dun-

woody's Tables (Report 1876, pp. 354–360), and for stations whose altitude exceeds 1,200 feet, the reduction was also determined by my tables contained in Guyot's collection of Hypsometrical Tables as published by the Smithsonian Institution, pp. 52–3. The observations at Mt. Washington and Pike's Peak, have not been employed in these comparisons.

The following table shows the data for the month of January. Column 5th shows the mean height of the barometer as determined at each of the stations; column 6th shows the mean temperature of each station and differs slightly from the numbers given on page 90, as it includes the observations of an additional year; column 7th shows the estimated temperature at the level of the sea directly under each station, and differs

January observations.

Stations.	Lat.	Long.	Altitude.	Mean barom.	Temperature.		Reduc. barom.		Diff.
					Station.	Sea lev.	Dunwoody.	Loomis.	
Santa Fé	35°·7	106°·2	7000	23·196	28°·4	46°·2	·189	·198	—·009
Dodge City	37·6	100·1	2486	27·454	26·1	39·3	·176	·181	—·005
Denver	39·7	105·1	5269	24·721	26·1	36·5	·211	·234	—·023
N. Platte	41·1	100·9	2838	27·093	18·3	30·0	·249	·255	—·006
Cheyenne	41·2	104·7	6057	23·922	23·6	32·3	·185	·193	—·008
Salt Lake C.	41·2	112·0	4362	25·660	29·1	38·1	·271	·288	—·017
Yankton	42·7	97·5	1275	28·809	11·8	24·3	·288	·290	—·002
Virginia C.	45·3	112·0	5694	24·168	17·9	29·1	·135	·159	—·024
Bismark	46·8	100·6	1706	28·228	5·7	18·0	·214	·216	—·002

somewhat from the numbers given on page 90 for the reason just stated; column 8th shows the height of the barometer reduced to sea-level by Dunwoody's Tables (30 inches being omitted); column 9th shows the height of the barometer reduced by Loomis' Table, and column 10th shows the differences between the numbers in the two preceding columns. It will be perceived that these differences are small, showing that Dunwoody's Tables accord very well with Laplace's formula.

Plate II shows the isobars drawn to represent the preceding observations and also those at the other stations of the Signal Service, together with a few observations beyond the limits of the United States contained in Buchan's paper on the mean pressure of the atmosphere (Ed. Trans., vol. xxv, pp. 575–637). These curves bear a pretty close resemblance to those derived from my first collection of observations. There is a similar area of maximum pressure having its center near Salt Lake City; there is an area of maximum pressure whose center is near Yankton, and there is an area of maximum spread out over the Southern States. In the latter area, the isobar of 30·2 inches extends further to the northeast than was previously

found, but the general features of the curves are but little changed. The breaking up of the area of high pressure into three subordinate areas is distinctly indicated, and it is scarcely to be expected that this feature will be made to disappear by a longer continuance of the observations. It appears probable that there is a permanent cause for this peculiarity, and it may perhaps be ascribed to the usual course pursued by barometric minima. The centers of great storms, particularly in winter, generally follow the eastern slope of the Rocky Mountains until they reach latitude 40° or a little further south, after which they turn eastward and soon incline somewhat to the north of east. This low barometer is partly compensated by the high pressure which succeeds it, but this compensation is apparently not quite complete.

The following table shows the data for the month of July for the same stations named in the table on page 94, and the arrangement of the table is the same.

July observations.

Stations.	Alti-tude.	Mean barom.	Ther-mom.	Reduc. barom.		Diff.
				Dun-woody.	Loomis.	
Santa Fé	7000	23·353	69°02	29·863	29·884	—·021
Dodge City	2486	27·403	77·53	·859	·869	—·010
Denver	5269	24·873	73·16	·884	·902	—·018
North Platte	2838	27·065	74·77	·872	·879	—·007
Cheyenne	6057	24·143	69·60	·854	·883	—·029
Salt Lake City	4362	25·628	76·84	·798	·816	—·018
Yankton	1275	28·674	74·18	·974	·979	—·005
Virginia City	5694	24·339	64·54	·788	·809	—·021
Bismark	1706	28·143	70·17	·880	·884	—·004

It will be noticed that the differences between the results by Dunwoody's Tables and my own are quite small, showing that Dunwoody's Tables give very good results for altitudes as great as 7,000 feet, for summer as well as winter.

Plate III shows the isobars drawn to represent the preceding observations as well as those at other stations of the Signal Service. These curves bear a close resemblance to those derived from my first collection of observations. The area of minimum pressure extends from Salt Lake City northward, and the pressure increases on each side of this area, but most rapidly on the west side. These curves generally represent the observations very well; but there are some exceptions, particularly at the stations between the Rocky Mountains and Lake Michigan. The greatest discrepancy is at Yankton, where the observed height exceeds that shown on the chart by 0·07 inch; while at Chicago the observed height is less than the chart by

0·05 inch. The observations make the pressure at Dodge City 0·03 inch less than at Denver, while the chart makes the former 0 025 inch greater than the latter. A part of these discrepancies may be ascribed to the fact that the observations at the different stations were not all made on the same years. According to the Dakota Southern Railroad Survey the elevation of Yankton is 1,202 feet. If we adopt this value, both the January and July observations at Yankton accord pretty well with the observations at neighboring stations. The observations at Chicago seem to indicate a small zero error in the barometer.

The pressure at Salt Lake City reduced to sea level appears to be 0·472 inch greater in winter than in summer; while in Central Asia the difference between winter and summer amounts to an entire inch. It is evident that the same cause operates in North America as in Asia, but with diminished energy.

Comparison of barometric minima in Europe and America.

The monthly Review of the weather for 1877 published by Dr. Neumayer of Hamburg, contains a summary of the results derived from the observations of 1876 and 1877. I propose to compare some of these results with those obtained in the United States.

Rate of progress of barometric minima.—Dr. Neumayer has given for each month of the years 1876 and 1877 the average daily progress of barometric minima in Europe expressed in myriameters. I have reduced these values to English miles per hour, and the results are shown in column 4th of the following table. For the purpose of comparison, I have placed in column 2nd the velocities deduced from three years observations in the United States as published in this Journal, vol. x, p. 1. I have also reduced to a tabular form the velocities given in the monthly Reports of the Signal Service since Nov. 1875,

	Loomis.	Sig. Ser.	Europe.		Loomis.	Sig. Ser.	Europe.
January	26·7	33·3	15·8	July	24·9	27·6	14·7
February	32·0	28·5	14·0	August	18·4	22·8	14·5
March	30 5	30·2	18·2	September	22·9	21·5	15·0
April	27·5	24·1	14·9	October	25·8	21·4	19·7
May	23·5	23·6	12·7	November	29·0	25·5	15·8
June	21·6	23·6	14·5	December	29·3	34·0	15·8
				Year	26·0	26·3	15·5

and have determined the averages for each month. These results are shown in column 3d of the table. They are derived from forty-four months of observation, and refer to the region between the Atlantic Ocean and the meridian of 100° from Greenwich.

The average velocity of storm centers as shown by the monthly Reports of the Signal Service is almost identical with that which I had previously deduced. As these two results are based on the observations of six and two-thirds years, it is probable that they will not be greatly changed by a longer continuance of the observations. Dr. Neumayer's result is deduced from observations of two years, extending over every part of Europe, and is probably a close approximation to the average velocity of storm centers in that country. The average velocity of storm centers in the United States is seen to be 69 per cent greater than it is in Europe. In my tenth paper (this Journ., vol. xvii, p. 3) I determined the average velocity of storm centers on the Atlantic Ocean to be 14 miles per hour, which is somewhat less than the value above found for the continent of Europe.

It appears then to be an established fact that storms travel more rapidly over the eastern portion of the United States than they do over the Atlantic Ocean or the continent of Europe. What cause can be assigned for this inequality? The winds on the Atlantic Ocean are certainly stronger than they are over either of the continents, and it is believed that the winds of Central Europe are generally stronger than the winds of the United States. In my eighth paper (this Journ., vol. xv, p. 16) I gave the results of an extended comparison of the winds at the Signal Service stations. For the stations north of latitude 40° (omitting Mt. Washington and Pike's Peak) the average velocity is 8·7 miles per hour. The average velocity which I have deduced from a considerable number of stations in England and its vicinity is 11·3 miles per hour. The average velocity at several stations in Northern Prussia is 11·8 miles per hour, and the average velocity at Vienna is 11·5 miles per hour. In my first paper (this Journ., vol. viii, p. 7) from a comparison of a large number of cases, I showed that generally the stronger the wind on the west side of a storm, the less the velocity of the storm's progress. If the more rapid progress of storm centers in the United States results from a difference in the velocity of the winds, it seems probable that the effect is produced by means of the vapor which is precipitated. From the Rocky Mountains to the Atlantic Ocean storms advance from a dryer to a more humid atmosphere. In Europe, while storms travel eastward, they advance from a humid to a dryer atmosphere. Upon the Atlantic Ocean the vapor on the western side of storm centers generally has a greater tension than it has upon the eastern side, owing to the warm water of the Gulf Stream. In my eighth paper (this Journ., vol. xv, p. 11) I have shown that in the vicinity of Newfoundland storms are frequently delayed several days, and this result is apparently

due to the abundant precipitation of vapor in that region. In my first paper (this Journ., vol. viii, p. 6) I have shown that when a storm center advances eastward most rapidly, the rain-area generally extends to an unusual distance on the east side; and the storm center advances less rapidly than usual when the rain-area extends but little on the east side. These facts seem to indicate that in Europe the center of the rain-area must precede the center of least pressure by a less distance than it does in the United States. I have endeavored to decide this question by a comparison of observations. The most satisfactory course would probably be to determine the position of the rain-center with reference to the point of least pressure, for a large number of cases in Europe and America; but unless we take all the storms of a year indiscriminately, we might be charged with having selected cases for the purpose of establishing a preconceived hypothesis. I have therefore adopted a different method, and have taken all those stations both in Europe and in the United States for which I could obtain a record of the rain-fall, as well as of the barometer, more than three times a day. I then divided the rain of each month into two portions, one containing the rain which fell while the barometer was descending, and the other containing the rain which fell while the barometer was ascending. Whenever it happened that the barometer remained stationary during the interval between two observations, the rain for that period was divided equally between the two columns. The materials which I have been able to obtain for this comparison are the following:

1. Observations made at Girard College, Philadelphia, from 1840 to 1845. For three years the observations were made hourly and for the other year once in two hours. 2. Hourly observations at Valencia, Armagh, Glasgow, Aberdeen, Falmouth, Stonyhurst and Kew for 1874. 3. Observations eight times a day at Paris for 1877. 4. Observations once in two hours at Brussels for six months of 1879. 5. Hourly observations at Prague for 1865, '66 and '69. 6. Hourly observations at Vienna for 1854, '55 and '56. These are all the stations in Europe and America for which I have been able to obtain observations of the rain-fall and barometer more frequently than three times a day. The results are shown in the following table, and are all expressed in English inches. When the observations at any station were continued more than one year, the average fall for all the years has been taken. The first column under each station shows the monthly fall of rain while the barometer was descending, and the second column shows the fall of rain while the barometer was rising. At the bottom of the table is shown the total fall for the year, and the last line shows the ratio of the total numbers in the two columns.

We see that at Philadelphia the amount of rain which falls while the barometer is descending, is nearly three times as great as that which falls while the barometer is rising, and during the six colder months of the year the rain-fall in the former

Relation of rain-fall to barometric pressure.

	Philadelphia four years.		Valencia one year.		Armagh one year.		Falmouth one year.		Glasgow one year.		Stonyhurst one year.	
	Fall.	Ris'g	Fall.	Ris'g	Fall.	Ris'g	Fall.	Ris'g	Fall.	Ris'g	Fall.	Ris'g
Jan.	2·36	0·42	2·90	2·04	1·46	0·49	3·52	2·92	2·13	1·18	3·38	1·54
Feb.	1·20	0·29	3·62	1·46	1·64	·31	2·95	·85	·53	·28	1·11	·63
March	2·06	0·33	1·65	1·01	1·08	·49	·89	·76	2·24	·70	5·26	·95
April	2·34	0·97	2·64	1·31	·88	·70	1·83	·83	1·02	·72	1·15	·49
May	1·95	0·58	·60	·44	·91	·18	1·05	·21	1·99	·50	·65	·98
June	2·22	0·58	·93	·53	·46	·37	1·85	·87	·63	·15	1·16	·35
July	2·03	2·63	3·31	1·65	·22	·70	1·15	·56	2·69	·99	1·97	1·07
Aug.	3·98	1·39	4·03	1·27	2·05	1·75	2·93	·67	3·14	1·24	3·95	3·07
Sept.	1·67	0·50	4·14	2·23	1·96	1·20	4·04	1·96	2·50	1·50	3·38	2·09
Oct.	1·43	0·52	5·28	1·96	2·60	1·04	5·01	1·60	5·57	1·62	3·69	2·95
Nov.	2·60	0·48	3·45	1·08	2·12	·76	3·84	·76	2·61	1·15	3·19	1·40
Dec.	3·19	0·68	5·17	2·06	1·91	·91	6·44	2·66	1·66	·41	2·81	·85
Year	27·03	9·37	37·72	17·04	17·29	8·90	35·50	14·65	26·71	10·44	31·70	16·37
Ratio	2·88		2·21		1·94		2·42		2·56		1·94	

	Aberdeen one year.		Kew one year.		Paris one year.		Brussels six months.		Prague three years.		Vienna three years.	
	Fall.	Ris'g	Fall.	Ris'g	Fall.	Ris'g	Fall.	Ris'g	Fall.	Ris'g	Fall.	Ris'g
Jan.	1·04	0·27	0·53	0·43	1·55	0·56			0·30	0·27	0·88	0·42
Feb.	1·25	·43	·82	·29	·55	·37	1·59	1·56	·78	·46	·57	·58
March	·65	1·97	·22	·21	·51	·15	·30	·50	·80	·86	·12	·22
April	·55	·53	1·04	·22	·83	1·45	1·52	·90	·31	·55	·08	·32
May	·75	·64	·33	·27	0	0	·76	·53	·47	·76	1·13	1·02
June	1·00	·12	1·55	·99	2·58	1·94	1·02	2·79	1·00	1·34	1·04	1·09
July	1·18	1·16	·88	·39	1·68	1·07	1·93	2·82	·63	1·41	·42	2·26
Aug.	3·99	2·69	1·04	·24	·64	·64			·60	1·16	1·10	1·45
Sept.	1·23	·96	2·07	·73	1·61	·47			·10	·52	·47	1·02
Oct.	1·23	1·06	2·00	1·72	·71	·87			·10	·48	·49	·42
Nov.	2·35	1·36	1·52	·62	·28	·09			·76	·53	1·30	·52
Dec.	·90	2·03	1·12	·42	·59	·15			·57	·41	·73	·35
Year	16·12	13·22	13·12	6·53	11·53	7·76	7·12	9·10	6·42	8·75	8·33	9·67
Ratio	1·22		2·01		1·49		0·78		0·73		0·86	

case is nearly five times as great as in the latter case. In summer there frequently occurs a thunder shower with an excessive fall of rain accompanied by a slight rise of the barometer, and this affords the explanation of the fact that in July more rain occurs with a rising than with a falling barometer.

At the stations near the west coast of Great Britain and Ireland, the amount of rain with a falling barometer is more than twice that with a rising barometer; but this ratio rapidly dimin-

ishes as we advance eastward. At Paris this ratio is reduced to one and a half; and in Central Europe more rain falls while the barometer is ascending than while it is descending.

From these observations we must conclude that storms may travel eastward even though the center of the rain-area is somewhat west of the center of low pressure. In my tenth paper (this Journ., vol. xvii, p. 12) I have shown that the change of wind which accompanies a barometric minimum generally begins at the surface of the earth, before it does at elevated stations, indicating that the west wind in the rear of the storm pushes under the east wind, lifting it from the surface of the earth, so that a change of wind and an increase of barometric pressure is observed at the surface before there is any change of wind at the elevation of 2,000 or 3,000 feet. This movement of the winds does not prevent the storm center from advancing eastward, but the storm advances less rapidly than when the center of the rain-fall is considerably east of the center of low pressure, as is generally the case in the United States.

Barometric minima advancing with unusual velocity.

Dr. Neumayer finds in Europe occasional examples of barometric minima which remain nearly stationary for a few days; and there are other examples of minima which advance with extreme rapidity.

On the 9th of September, 1876, there was a barometric minimum (29·06 inches) not far from Königsberg in Prussia. Thence it made a circuit through the southern part of Sweden and Norway, and at the end of six days it was in Holland about 720 miles west of the first named position. On the 19th of December, 1876, there was a barometric minimum (28·70 inches) near the southern extremity of Ireland. Thence it made a circuit through England and back into Ireland, and at the end of six days was near Cherburg in France, less than 500 miles distant from the point first mentioned.

The following table shows all the cases in 1876 and 1877 in which storm centers advanced over 1000 miles in twenty-four hours.

Column 3d shows the progress of the barometric minimum in twenty-four hours expressed in English miles; column 4th shows the height of the barometer (in English inches) at the center of the storm at the beginning of the day in question; column 5th shows the latitude of the center at the beginning of the given day; column 6th shows the height of the barometer at the center of the storm at the end of the given day; column 7th shows the latitude of the center at that instant; column 8th shows the force of the strongest wind reported at any station for that day. The scale is not

stated but is supposed to be 1 to 12. Column 9th shows the different directions of the winds whose force is given in the preceding column.

No.	Date.	Progress, miles.	Barom. Eng. inch.	Lat.	Barom. Eng. inch.	Lat.	Wind.	Direction.
	1876.							
1	Aug. 25–26	1000	29·37	43°·8	29·29	57°·3	8	N.; W.; S.W.; S.E.
2	Oct. 10–11	1330	29·13	57·0	29·21	56·0	10	W.S.W.; S.W.
3	Oct. 12–13	1094	28·66	62·2	28·74	68·0	10	W.N.W.; S.W.; S.S.W.
4	Oct. 14–15	1131	29·25	63·2	29·45	65·0		
5	Dec. 2– 3	1031	29·13	54·0	29·13	54·0	10	S.S.W.; E.S.E.; E.
6	Dec. 5– 6	1174	28·35	51·8	28·35	57·2	10	E.N.E.; E.S.E.
	1877.							
7	Jan. 1– 2	1243	28·66	51·8	28·70	59·7	10	S.W.; E.
8	Jan. 9–10	1019	29·29	60·2	29·13	63·5	9	S.W.
9	Jan. 19–20	1190	29·06	53·0	29·13	66·0	8	S.W.; S.S.W.; S.; S.S.E.; S.E.
10	Feb. 10–11	1156	----	55·5	29·13	55·0	9	W.; W.S.W.; S.W.
11	Oct. 14–15	1007	28·82	66·0	29·13	66·0	10	W.N.W.; S.S.W.; S.

It will be seen that the number of European cases in which storms advance 1000 miles in a day, amounts to 11 in two years, being an average of 5½ cases annually; the greatest rate of progress observed is 1330 miles in a day; these storms generally advanced toward a point north of east, and in no case was there a considerable movement toward the south of east; the average height of the barometer at the center was 29·0 inches; and they were all accompanied by winds of great violence.

In the United States, the cases in which storms advance with a high velocity are of much more frequent occurrence, and they sometimes attain a velocity greater than has been observed in Europe, but the amount of the barometric depression is much less. In my first paper (this Journ., vol. viii, p. 4) I alluded to these examples of high velocity, and showed that in these cases the rain-area extended eastward of the storm's center to an unusual distance. The same subject was further considered in my third paper (this Journ., vol. x, p. 6).

I now present a summary of the cases in which barometric minima advanced at least 1000 miles in a day, during the period for which the observations of the Signal Service have been published entire, viz: Sept., 1872, to Jan., 1875, and January to March, 1877. In the following table, column 1st gives the number of reference; column 2d gives the date of commencement of the day in question, where 1 denotes the 7·35 A. M. observation, 2 the 4·35 P. M. observation, and 3 the 11 P. M. observation; column 3d shows the distance in English miles that the storm advanced in twenty-four hours; column 4th (increased by twenty-eight inches) shows the height of the barometer at the center of the low area at the beginning of

the given day; column 5th shows the station at which the height mentioned in the preceding column was observed; column 6th (increased by 28 inches) shows the height of the barometer at the center of the low area at the end of the given day; column 7th shows the station at which the height mentioned in the preceding column was observed; column 8th shows the direction and velocity (in miles per hour) of the highest wind at any of the stations near the low center during the given day; column 9th shows the direction and velocity of the highest wind on Mt. Washington observed during the progress of the storm or immediately after the storm had passed eastward; column 10th shows the total rainfall at the Signal Service stations within the low area (barometer below thirty inches) during the day in question; column 11th shows the distance that the rain area extended eastward of the center of least pressure; column 12th shows the distance eastward from the storm-center that abnormal winds extended (that is, winds from S., S.E., E. or N.E.); column 13th shows the direction of an area of high barometer, with reference to the low center; and column 14th (increased by thirty inches) shows the greatest height of the barometer within the high area mentioned in the preceding column.

Besides the cases here enumerated there are a few others in which storms may have advanced with equal rapidity, but there is so much uncertainty with regard to the exact position of the center of least pressure that I have preferred to leave them out of the account. The number of cases in the table is 39, occurring within a period of 32 months which gives an average of 14 per year, being 2½ times as many as occur in Europe. The greatest observed velocity of these low areas was 1872 miles per day, which is 40 per cent greater than the highest velocity observed in Europe.

The average height of the barometer at the beginning of the days enumerated was 29·62 inches, and the average height at the end of the days was 29·42 inches, which is only half of the average depression observed in the storms of Europe. In 27 of these cases the depression at the center of the storm increased during the day, in 11 cases it decreased, and in one case it remained stationary. In each of these last 12 cases except Nos. 31, 37 and 38, the center of low barometer passed north of the United States, and it is doubtful whether the lowest barometer was observed. Thus we see that in the American cases, the storms generally increased in intensity, while in the European cases there was a slight diminution of intensity.

The highest wind recorded at any station during the days in question (excluding Mt. Washington and Pike's Peak) ranged

Barometric minima advancing at least* 1000 *miles in* 24 *hours.

Date.	Progress, miles.	Barometer, inches.	Station.	Barometer, inches.	Station.	Highest wind.	Wind on Mt. Wash.	Rain.		Abnor. winds, miles.	High Bar	
								In Low, inches.	Extent, miles.		Direction.	Amount, inches.
1872.												
Nov. 6.2	1376	1·45	Pembina	1·12	Portland	N. 41	N.W. 65	15·08	1357	1357	S.E.	·19
24.2	1214	1·62	Keokuk	1·39	Quebec	W. 36	W. 85	0·44	429	1056	S.E.	·30
Dec. 14.1	1132	1·67	Omaha	1·51	Montreal	N.W. 32	N. 68	0·18	134	541	S.E.	·45
19.1	1295	1·70	Indianola	1·43	Buffalo	N.E. 33	N.E. 55	11·59	650	1220	N.E.	·52
1873.												
Jan. 4.3	1215	1·74	Memphis	1·33	Portland	N.E. 42	S. 64	30·66	462	983	N.E.	·35
26.3	1404	1·80	Lake C'y	1·17	Halifax	N. 40	W. 54	9·71	944	1118	N.E.	·21
Feb. 15.3	1055	1·59	Memphis	1·53	N. London	N.E. 36	N.E. 60	20·19	948	1042	N.E.	·48
May 12.2	1145	1·44	St. Paul	1·35	Portland	N. 30	N.W. 72	3·22	318	543	S.	·08
Nov. 3.3	1100	1·49	Duluth	1·60	F. Point	N. 30	N.W. 65	0·00	000	727	S.E.	·36
23.1	1270	1·73	Indianola	1·48	Pittsburgh	N.E. 47	N.W. 72	11·57	1058	1270	N.E.	·48
24.1	1002	1·48	Pittsbu'gh	0·82	Halifax	N.E. 59	N.W. 72	28·39	640	917	N.E.	·34
1874.												
Jan. 3.3	1000	1·31	Escanaba	1·55	F. Point	N. 40	S.W. 80	4·92	00	1270	S.E.	·33
Feb. 6.2	1212	1·82	Louisv'e	1·70	Sydney	S.W. 36	N.W. 108	11·94	780	728	N.E.	·36
19.1	1123	1·52	Duluth	1·70	F. Point	S.W. 67	S. 72	1·54	846	1030	S.E.	·44
22.1	1374	1·89	Indianola	1·58	Rochester	E. 65	W. 92	3·44	1226	1700	E.	·27
23.1	1058	1·58	Roches'r	1·47	F. Point	E. 65	W. 92	9·76	783	947	S.E.	23
March 3.1	1114	1·29	Leaven'th	1·34	Ottawa	S. 35	S.W. 96	12·30	676	1424	S.E.	·13
18.2	1187	1·63	Keokuk	1·19	Quebec	W. 35	N.W. 110	15·83	1011	1607	E.	·24
April 5.1	1065	1·71	St. Louis	1·63	Ottawa	S.W. 40	N.W. 60	8·45	488	663	E.	·51
Sept. 2.1	1175	1·89	St. Paul	1·72	F. Point	N.W. 18	N.W. 82	0·96	360	464	S.E.	·22
Nov. 28.1	1466	2·15	Mobile	1·54	Quebec	N.E 50	N.W. 100	1·04	1025	1080	N.E.	·48
Dec. 2.2	1095	1·44	Marqu'e	1·64	C. Rozier	N.W. 41	N.W. 76	0·33	596	744	S.E.	·38
13.2	1092	1·83	Cleve'nd	1·42	Halifax	N. 52	N.W. 98	6·17	668	835	S.E.	·25
16.1	1065	1·51	Omaha	1·59	Ottawa	N.W. 40	N.W. 85	5·65	572	1170	S.E.	·56
23.2	1165	1·49	Marqu'e	1·37	Halifax	W. 39	N.W. 80	1·63	426	640	S.E.	·16
27.2	1134	1·59	Bismark	1·59	Quebec	S.W. 30	N.W. 100	8·91	663	956	S.E.	·21
1875.												
Jan. 1.3	1170	1·94	Marqu'e	0·89	Halifax	W. 44	N.W. 90	15·59	668	671	S.E.	·43
1877.												
Jan. 1.1	1126	1·62	St. Marks	1·35	Boston	E. 50	N.W. 100	21·25	643	936	N.E.	·21
6.1	1048	1·84	Mobile	1·15	New York	N.W. 68	N.W. 96	12·72	577	1223	N.E.	·33
7.3	1872	1·84	Indianola	1·37	Eastport	N. 52	N.W. 96	4·08	1080	922	S.E.	·09
15.1	1270	1·45	F. Gibson	1·56	Malone	N. 48	N.W. 84	20·68	1158	1275	N.E.	·35
19.1	1080	1·63	Bismark	1·19	Parry S.	N.W. 36	N.W. 96	1·55	321	840	S.E.	·35
March 1.2	1003	1·56	Memphis	1·07	Parry S.	S. 42	N.W. 84	23·21	905	991	E.	·23
3.2	1178	1·61	Indian'lis	1·52	F. Point	S. 31	N.W. 102	9·89	758	958	S.	·19
6.2	1055	1·59	Escanaba	1·71	Chatham	W. 32	N.W. 72	3·25	270	705	S.	·33
8.2	1061	1·16	Cincin'i	0·74	F. Point	S. 50	N.W. 72	36·24	1080	1080	N.E.	·43
15.3	1050	1·56	Dodge C.	1·64	Knoxville	N.W. 44	N.W. 60	3·57	839	839	S.E.	·18
18.3	1209	1·66	Leaven'th	1·87	C. Henry	N.W. 40	N.W. 60	1·11	457	1206	S.E.	·32
20.2	1047	1·55	St. Louis	1·57	Malone	N. 36	N.W. 60	11·89	593	1037	E.	·30
Means		1·62		1·42		42·1	80·4	9·97	667	993		

from 18 to 68 miles per hour. In the case of No. 20, winds higher than 18 miles per hour prevailed in other parts of the United States, but it is doubtful whether they ought to be regarded as belonging to the storm here investigated. The average of the numbers in this column of the table is 42 miles per hour. The number of cases for the different points of the compass is shown in column 2d of the following table.

	Cases.	Mt. W.		Cases.	Mt. W.
North	9	1	South	4	2
North West	8	28	South East	0	0
West	5	4	East	3	0
South West	4	2	North East	6	2

Thus we see that in 28 of the cases, the highest wind came from the quarters N.E., N., N.W. and W.; and in only 11 of the cases did they come from the quarters S.W., S., S.E. and E. The average direction of these violent winds was about N.N.W. while in Europe it was but a little west of south.

On Mt. Washington the highest winds range from 54 to 110 miles per hour, the average being 80 miles. The number of cases for the different points of the compass is shown in column 3d of the preceding table, and we see that in 35 of the cases the highest wind came from the points N.E., N.W. and W.; while in only 4 of the cases did they come from the points S.W., S., S.E. and E.

The average rainfall in 24 hours within these low areas was 9·97 inches, which is considerably in excess of the usual rainfall at the same stations. The amount of the rain was however very variable, ranging from 0 to 36 inches; and there were ten cases in which the total rain-fall within the low area was less than two inches in 24 hours. In 6 of these 10 cases the storm center passed beyond the northern boundary of the United States or very near to it, and it may be claimed that probably there was rain on the north side of these low areas; but in Nos. 2, 3 and 38, the center of the low area was 500 miles south of our northern boundary. No. 21 was a peculiar case. On the morning of Nov. 28, 1874, the lowest barometer at any of the signal service stations was 30·15 inches, so that the barometer at Mobile was only *relatively low*, the pressure being unusually high from the Atlantic to the Pacific Ocean. In preparing column 8th of the table, it was necessary to have a uniform rule which could be applied without bias, and I have regarded the term low as including all stations surrounding the storm center, where the barometer was below 30 inches. This rule indicated no rain for the morning and afternoon observations of Nov. 28th, although in fact there was a great fall of rain and snow within the system of winds which

circulated about Mobile. If all this precipitation is regarded as belonging to the storm No. 21, it makes a total of 17·60 inches for that day. No. 15 presents another case in which the rain-fall in column 8th is made to appear very small in consequence of the rule above stated, but if all the rain included within the system of circulating winds for that day were counted, the total would be 12·19 inches. We see then that these cases of fast moving barometric minima were generally accompanied by a large rain-fall; but there are apparently some cases in which the rain-fall which can be associated with these low areas was very slight. Such were Nos. 2, 3 and 38.

The area of rain generally extended a great distance in advance of the storm center, the average distance being 667 miles, but there were several cases in which the rain extended but little eastward of the storm center. These were generally cases in which the rain-fall shown in column 10th was very small, but No. 12 was a case in which the rain-fall was considerable, yet for each period of eight hours the rain did not extend sensibly eastward of the center of least pressure at the close of the eight hours. This implies that the rain did actually extend eastward of the low center to a distance equal to the space traveled over by the storm center in about four hours, that is, 200 miles; but on the morning of January 4th the center of the rain area very nearly coincided with the center of least pressure, and was apparently a little westward of that center.

The abnormal winds generally extended on the east side of the low center to a distance of about 1,000 miles, the average being 993 miles. By abnormal winds I understand winds from the south, southeast, east or northeast. No. 20 is the only instance in which this distance was less than 500 miles; and in this case there was another low center at a distance of 1,500 miles on the east side, the two being separated by a narrow ridge of higher pressure, in which the highest barometer was 30·15 inches. This ridge of higher pressure separated two systems of circulating winds, and was apparently levelled before the morning of September 3d.

What now is the cause of these rapid movements of storm centers? Several of them apparently resulted from the mutual influence of two low areas. In my 10th paper (this Journ., vol. xvii, p. 5) I showed that on the Atlantic Ocean two low areas frequently become merged in one. In such cases the eastern low area is generally retarded in its progress, and is sometimes turned backward toward the west. At the same time the progress of the western low area must be accelerated. Such cases appear to occur within the limits of the United States, or near our borders, although the geographical extent of the weather maps is too small to exhibit the full development of

these changes. Nos. 3, 6, 8, 9, 13, 15, 18, 19, 20, 25, 27, 28, 29, 30, 33, 34, 35, 37 and 38 were apparently of this kind.

The maps accompanying the Hamburgh Review for January, 1877, clearly show that No. 7 of the cases on page 101 belongs to this class. I have no information which enables me to judge of the other European cases on page 101.

The cases of barometric minima enumerated in the table on page 103 were all accompanied with high winds and some of them with violent winds; they were generally accompanied with a great fall of rain or snow, and the rain-area generally extended to a great distance in front of the storm's center; but the most noticeable circumstance which characterizes all the cases is the great extent of abnormal winds in front of the storm's center. These abnormal winds were apparently due to an area of high barometer situated on the south, southeast, east or northeast side of the low center. These winds (in consequence of the rotation of the earth) tend to produce a depression of the barometer on their left side. They were generally accompanied with a considerable rain-fall, which tends to increase the velocity of the winds and thus produce a greater depression of the barometer.

In order to illustrate more clearly the operation of these different causes, I have prepared Plate IV, which shows the isobars and winds for January 15, 1877, at 4.35 P. M. (case No. 31 of the table on page 103). We see that the center of the low area was between Cincinnati and St. Louis, the lowest pressure recorded being 29·39 at Cincinnati. Around this center the isobars are arranged with considerable symmetry, but are crowded most closely together on the northwest side, and we find an area of high pressure (30·46) whose center is not far from Breckenridge. Also on the northeast side near the margin of the chart, we find another area of high barometer (30·35). The winds tend from these high centers toward the low center, but by the rotation of the earth they are deflected to the right, thus producing an increased pressure on the right of their course, and a diminished pressure on their left. The movement due to these causes would soon cease if there were no recruiting force. This force is supplied by the precipitation of the vapor which is present in the air. When this vapor is condensed, the neighboring air rushes in with great force to supply the place of the condensed vapor, and the air is expanded by the latent heat which is set free. This cause is sufficient to maintain high winds as long as there is a great precipitation of vapor.

On Plate IV the direction of the wind is indicated by arrows; and the force of the wind is indicated by the number of feathers attached to the end of the arrows. One feather indicates a

velocity not exceeding five miles per hour; two feathers indicate a velocity from six to ten miles; three feathers from eleven to fifteen miles; four feathers from sixteen to twenty miles, and so on for higher velocities.

The center of low pressure advanced eastward along the dotted line represented on Plate IV. Some have claimed that this advance of storms is simple *drift*, the entire mass of air within the low area being carried bodily eastward, that being the average direction in which the atmosphere moves in the middle latitudes. This explanation will not stand examination. If while the winds are circulating around a low center, the entire atmosphere within the low area is carried bodily eastward, the effect of this movement should be different upon the northern and southern portions of the storm. In my former papers I have shown that on the north side of low areas in the United States the average direction of the wind is nearly northeast, and on the south side it is from the southwest, and the average velocity of the winds on both sides is nearly the same, viz: eight miles per hour, while the average progress of the low center is twenty-six miles per hour. Suppose now the velocity of progress to be increased to fifty miles per hour, if the entire mass of air within the low area is carried bodily eastward, the velocity of the wind relative to the earth's surface should be greatly increased on the south side of the low area, while that on the north side should be diminished, and the direction of the wind on each side should be materially changed. But we see from Plate IV that on the north side of the low center the winds blow from the northeast with an unusual velocity, while those on the south side generally blow from the southwest and are comparatively feeble. If we compare the stations within the isobar 29·9 we find that on the north side of the track of the storm, the average velocity of the winds is 14·9 miles per hour, and on the south side it is 8·5 miles; that is, on the north side the average velocity of the winds is seventy-five per cent greater than it is on the south side. The air within this low area did not then drift bodily eastward, but the eastward movement of the storm was due to some other cause.

The same conclusion applies to areas of high barometer, as will appear from a comparison of a few well-established facts. In a former paper I have shown that in the United States the average rate of motion of areas of high barometer is about twenty-five miles per hour. I have also shown that the winds blow outward from areas of high barometer, and therefore at the center there must be a *calm*, as observation generally indicates. If the area of high barometer was a mass of air advancing bodily from place to place at the rate of twenty-five miles per hour, the wind at the center should blow at the rate of

twenty-five miles per hour. We must then conclude that the progressive movement of areas of high barometer is like that of a wave, and its apparent motion results from a subtraction of air from one side and an addition of air to the opposite side.

The progress of areas of low barometer must be due to similar causes. The pressure is diminished on the east side of the low area and increased on the west side, in consequence of which the low center suffers a displacement with reference to the earth's surface, and the rate of progress of the low center will depend upon the rate at which the pressure is reduced on the east side, and restored on the west side.

The advance of storm centers across the United States may be affected by atmospheric conditions prevailing much beyond the limits of the signal service maps, so that we cannot be sure that we know all the circumstances which influence the case we are considering, but from Plate IV we can see a reason why the pressure on the west side of the low area should be rapidly restored. The air from the north and northwest rushed in with great velocity. This air had a very low temperature, the thermometer at 4.35 P. M. (Washington time) being below zero of Fahrenheit at Pembina, Bismark, Breckenridge, Fort Sully, Yankton, North Platte and Omaha. On the northeast side of the low center the wind was generally from the northeast, by which means the air was drawn off from that region and the pressure diminished. But if no other force operated, the low area would soon be filled up by these movements of the atmosphere, and the pressure would resume its normal state. This result is prevented by the condensation of the vapor which is present in the air. The rain which fell during the nine hours from 7.35 A. M. to 4.35 P. M. is exhibited on Plate IV by dotted lines. We see that a slight fall of rain or snow covered nearly the entire United States east of the meridian of 100°, but the greatest fall was at Louisville (1·56 inches in nine hours); and the area of one-quarter inch rain-fall extended from Lacrosse on the north, to Vicksburg on the south, and Boston on the east. The moist and warmer air on the east side of the low center rises from the earth's surface and is supplanted by the cold air which presses in upon the west side. The great extension of the rain area on the east side causes an unusually rapid fall of the barometer on that side, and a corresponding advance of the storm's center.

We have seen from the table on page 99 that in the middle latitudes, storms generally travel eastward, even though the principal rain-fall should be on the west side of the low center; but when the principal rain-fall is on the east side of the low center, this causes a diversion of the winds in that direction, and the low center travels eastward with increased rapidity.

During the entire progress of the storm of January 14–17, 1877, the winds on Mt. Washington blew uninterruptedly from the northwest, and the least velocity reported was thirty-six miles per hour, showing that the movements represented on Plate IV were confined to the lower stratum of the atmosphere and did not reach to the height of 6,000 feet.

Most of the cases enumerated in the table on page 103 agree with No. 31 in several of the particulars here stated. Their rapid movement eastward appears to have been due to an unusual extension of easterly winds which seem to have owed their origin to the accidental proximity of areas of high barometer, and the influence of this high barometer was sustained by the precipitation of vapor which extended to an unusual distance on the east side of the low center.

In the table on page 103 are a few cases to which the explanation here given does not seem to apply. The rapid movement of Nos. 2 and 3 was apparently due to their position between two areas of high barometer, one on the northwest side and the other on the southeast. In order to maintain these areas of high barometer, it seems necessary to admit the existence of rain in some region not shown by the Signal Service observations. These examples illustrate the importance of having observations from a large portion of the earth's surface, in order that we may fully investigate the phenomena of particular storms.

In preparing the materials for this article I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth college, of the class of 1871.

ART. XIII.—*On the Color Correction of Achromatic Telescopes; A reply to* Prof. CHAS. S. HASTINGS; by WM. HARKNESS.

IN the December number of this Journal, pages 434, 435, the distinguished Associate Professor of Physics of the Johns Hopkins University has criticised my theory of the color correction of achromatic telescopes in language which I quote here to avoid the possibility of misrepresenting it; merely adding numbers to the clauses for convenience of reference:

"These results are directly opposed to those of a recent writer in this Journal (Prof. Harkness in the Sept. number, pp. 191–193). But his conclusions arise from erroneous calculations. (I) Not only does his interpretation of his equation (12) imply the manifest absurdity that in a system of infinitely thin lenses in contact its properties are determined by the order of the lenses, but the interpretation is impossible. True A_2 should have an opposite sign to $A_1 + A_3$, but that asserts nothing as to likeness of the latter symbols in sign. (II) Thus n in equation (16) may be negative

and consequently his subsequent reasoning is fallacious, for in that case n does not have to be infinite to cause equation (27) to vanish. (III) I may add that the origin of the confusion is in making the ratio D $\div$ E in equation (9) constant; it may be, and of course should be, indeterminate."

"(IV) Professor Harkness has made another mistake, founded upon inadequate experiment, which has so important a bearing on the theory of the double objective that it should not be allowed to pass uncorrected. His statement (p. 191) concerning the condition for color correction is substantially correct, though in my opinion, it is not self-evident but requires proof. This proof I shall supply in a forthcoming number of the American Journal of Mathematics. (V) His experiment, however (p. 193), directly contravenes this principle, for he finds that the focal plane does not correspond to the minimum focal distance, but to something greater. (VI) The source of error is the introduction of a variable element in the system, namely, the eye, which would adjust itself differently in observing the star and its spectrum. Had the writer used eye-pieces of successively higher power, thus lessening progressively the power of accommodation of the system, with his prism, he would have seen his points γ_m and γ_s approach until they sensibly coincided; or better still had he formed his spectrum by a grating (such as perforated cardboard) before the objective, instead of by a prism between the ocular and eye, he could not have been misled, since the uncolored image would serve to control the eye."

"(VII) Finally, the fourth conclusion (p. 196) is strictly true, though we are not to conclude, as would seem from the text, that the detriment due to the secondary spectrum depends either solely upon the aperture or varies inversely as the focal length; * * *"

Let us examine this criticism in detail; referring to its clauses, and to the equations of my original paper, by their respective numbers.

Clause I virtually asserts that three quantities can be arranged in two classes otherwise than by putting one in one class and two in the other. To prove this we remark that equation (12) may be written

$$0 = A_1(b_1 + 2c_1\gamma_0^2) + A_2(b_2 + 2c_2\gamma_0^2) + A_3(b_3 + 2c_3\gamma_0^2) \quad (36)$$

For all glasses of which I have any knowledge, b is positive, and very much larger than c. The latter quantity is sometimes negative; but when this happens, it is exceedingly small. γ cannot be otherwise than positive. From these conditions it results that the quantities $(b + 2c\gamma_0^2)$ are invariably positive, and therefore the sign of each term in (36) depends solely upon the sign of its A. But in order that (36) may be true, one of its terms must have a different sign from the other two; and just because the properties of a system of infinitely thin lenses

in contact are independent of the order of the lenses; the choice of this term is arbitrary. Taking advantage of this circumstance to follow the usual practice of opticians, I made the middle lens different from the other two, and wrote

$$-A_2(b_2+2c_2\gamma_0^2) = A_1(b_1+2c_1\gamma_0^2) + A_3(b_3+2c_3\gamma_0^2) \quad (37)$$

But Clause I declares, "True A_2 should have an opposite sign to $A_1 + A_3$, but that asserts nothing as to likeness of the latter symbols in sign."—A statement which is manifestly untrue, unless it can be shown that three quantities can be arranged in two classes otherwise than by putting one in one class and two in the other.

Clause II asserts that n, in equation (16), may be negative. This is absurd, because $n = A_3 \div A_1$, and it has just been shown that the signs of A_1 and A_3 are always similar.

Clause III declares that $D \div E$ should be indeterminate; and that all my alleged errors arise from making it constant. Referring to equations (6), we see that

$$\begin{aligned} D &= A_1b_1 + A_2b_2 + A_3b_3 \\ E &= A_1c_1 + A_2c_2 + A_3c_3 \end{aligned} \quad (6)$$

The A's depend only upon the curves of the lenses, while the b's and c's depend only upon the physical properties of the glasses employed. In designing an objective D and E are both so far arbitrary that any glasses, and any curves, may be chosen; but when the objective is completed I certainly do hold that its curves, and the physical properties of the pieces of glass composing it, are constant. If I am right in this, it follows that both D and E, and also their ratio are constant; Clause III to the contrary notwithstanding.

Clause IV admits the accuracy of my statement that an objective is properly corrected for any given purpose when its minimum focal distance corresponds to rays of the wave-length which is most efficient for that purpose; but says the statement requires proof, and is not self-evident. With the law of dispersion assumed in equation (2), the focal curve can have but one tangent parallel to the axis of abscissas; and I did not suppose it necessary to tell the readers of this Journal that the parts of such a curve nearest the tangent line are those adjacent to the point of tangency. That consideration proves my proposition, and it is so elementary that I thought it self-evident. If more than two lenses, and a dispersion formula involving more than two powers of the wave-length, are assumed; I venture to say that the condition for color correction stated above cannot be proved. It may be true in special cases; but in general, the focal curve will have such a form as to give more than one minimum focal distance.

Clause V involves the assumption that the focal plane must be tangent to the focal curve at the point where the latter makes it nearest approach to the objective. No reason is assigned for this, and I do not believe any exists.

Clause VI virtually asserts that the focal distance of an objective is a function of the power of its ocular. For all astronomical instruments carrying filar micrometers, the first business of the observer is to place the wires accurately in the focus of the objective. This once done, they are not again disturbed, unless to make some radical change in the instrument. A dozen eye-pieces may be used in the course of a single evening; but no matter what their power, when they are focused upon the wires they are always found to be focused upon the objective. Hence, the focal plane always coincides with the wires. But the plane of the wires is fixed; and the focal curve, as I have defined it, is also fixed. Consequently, the points of intersection of the focal plane with the focal curve are fixed, and the universal experience of astronomers demonstrates that the positions of the points γ_m and γ_n do not vary with the power of the ocular.

As *Clause VII* affirms the correctness of my fourth conclusion, it is only necessary to express my thanks for such an indorsement; but I cannot refrain from adding that, since this clause rests upon equations condemned by my critic, there may be people wicked enough to inquire how these erroneous equations finally led to a correct result.

In this connection it is desirable to state that some months ago I investigated the relations existing in achromatic objectives between aperture, focal length and secondary spectrum. As the admissible limit of the latter of these elements is arbitrary, it is not possible to fix absolutely the relations between the other two; but I believe the focal distance should rarely be less than that given by the formula

$$F = (9{\cdot}04a^2 + 1296)^{\frac{1}{2}} - 36 \qquad (38)$$

in which F is the focal distance, in feet; and a the clear aperture in inches. For small apertures, the foci given by this expression are inconveniently short; while for large apertures, they considerably exceed those in general use.

Now consider a system of infinitely thin lenses in contact; and let us inquire how many lenses are needed in the system, to bring the greatest possible number of light-rays of different degrees of refrangibility to a common focus, with any given law of dispersion.

For this purpose we revert to equation (5), which may be written

$$f^{-1} = (\mu_1 - 1)A_1 + (\mu_2 - 1)A_2 + (\mu_3 - 1)A_3 + \&c. \qquad (39)$$

the number of terms being unlimited. For the dispersion formula, we write

$$\mu = \varphi(\lambda) \tag{40}$$

The form of $\varphi(\lambda)$ is regarded as unknown; but there will be no loss of generality if it is developed in a series arranged according to the powers of λ. We therefore have

$$\mu = a + b\lambda^m + c\lambda^n + e\lambda^p + \&c. \tag{41}$$

in which a, b, c, etc., are constants, and the number of terms may be taken as great as is desired. Also, let us put

$$\begin{aligned} C &= A_1(a_1 - 1) + A_2(a_2 - 1) + A_3(a_3 - 1) + \&c. \\ D &= A_1 b_1 - A_2 b_2 + A_3 b_3 + \&c. \\ E &= A_1 c_1 + A_2 c_2 + A_3 c_3 + \&c. \\ F &= A_1 e_1 + A_2 e_2 + A_3 e_3 + \&c. \\ &\&c. \quad \&c. \quad \&c. \quad \&c. \end{aligned} \tag{42}$$

the number of these equations, and the number of terms in the right hand member of each of them, being the same as the number of terms in the right hand member of (41). Then, by a simple transformation (39) becomes

$$f^{-1} = C + D\lambda^m + E\lambda^n + F\lambda^p + \&c. \tag{43}$$

This is the equation of the focal curve; λ being the abscissa, and f the ordinate. Its first derivative is

$$\frac{df}{d\lambda} = -f^2(mD\lambda^{m-1} + nE\lambda^{n-1} + pF\lambda^{p-1} + \&c.) \tag{44}$$

which, as is well known, expresses for every point of the curve the tangent of the angle made by the tangent line with the axis of abscissas. The number of rays of different degrees of refrangibility, which can be brought to a common focus, will evidently be the same as the number of times the focal plane intersects the focal curve. But the focal plane is necessarily parallel to the axis of abscissas; and therefore the greatest possible number of intersections of the curve with the plane can only exceed by one, the number of tangents which can be drawn parallel to the axis of abscissas. To find these tangents, we equate (44) to zero, and obtain

$$0 = mD + nE\lambda^{n-m} + pF\lambda^{p-m} + \&c. \tag{45}$$

As λ can never be either zero, imaginary, or negative, we have to consider only the real positive roots of this equation; each of which corresponds to a tangent. To make the number of roots as great as possible, the quantities D, E, F, etc., must be independent of each other; which will be the case when the right hand members of the equations (42) contain as many A's as there are powers of λ in (41). Hence it is evident that the number of real positive roots in (45) will be one less than the number of powers of λ in (41), and we conclude that—

In any system of infinitely thin lenses in contact, the number of lenses required to bring the greatest possible number of light-rays of different degrees of refrangibility to a common focus is the same as the number of different powers of λ involved in the dispersion formula employed.

The method used in deducing this result was adopted because it exhibits clearly the geometrical relations of the problem. The result itself is evident from a mere inspection of equation (43), which cannot possess more real positive roots than it has independent coefficients, D, E, F, etc.

The color correction of an objective depends only upon the form of its focal curve; which form is as much under control as the nature of the case admits when the coefficients D, E, F, etc., of equation (43), are independent of each other. This, taken in connection with what precedes, demonstrates that—

In an objective consisting of a system of infinitely thin lenses in contact, the color correction cannot be improved by increasing the number of lenses beyond the number of different powers of λ involved in the dispersion formula employed.

This result confirms the conclusion of my former paper, in which I used a dispersion formula involving but two powers of the wave-length, and consequently found but two lenses necessary in an achromatic objective. It also throws a curious light upon the general theory of achromaticity. If the law of dispersion had been such as could be expressed by a function involving but a single power of the wave-length, there would have been no irrationality of spectra, the mean dispersive powers might have been just what they now are, and yet, Newton would have been right in saying that achromatic telescopes were an impossibility. Conversely, the greater the number of powers of the wave-length involved in the dispersion function, the greater the number of rays of different degrees of refrangibility which can be brought to a common focus; and this, irrespective of any irrationality which may exist in the spectra. With rational spectra, and a law of dispersion involving at least two different powers of the wave-lengths, a pair of lenses would suffice for the construction of a perfectly achromatic objective. In strictness, these statements apply only to objectives consisting of infinitely thin lenses in contact. Possibly they may require modification when the thicknesses and distances apart of the lenses are considered.

The text books teach that the condition of achromatism for two thin lenses in contact is

$$0 = p_2 f_1 + p_1 f_2 \tag{46}$$

in which f_1 and f_2 are the foci, and p_1 and p_2 the dispersive powers, of the lenses. They further teach that it is sufficiently accurate to put

$$p=\frac{\delta\mu}{\mu-1} \qquad (47)$$

in which $\delta\mu$ is the difference, and μ the mean, of the refractive indices for the rays D and F. For a law of dispersion involving at least two different powers of the wave-length, these equations will hold; but for a law involving only a single power of the wave-length, they may be satisfied, and yet the system of lenses will not be achromatic. Instead of embodying, these equations are actually independent of, the essential condition of achromatism; which is that at least two rays of widely different wave-length must be brought to a common focus.

I have not had leisure to examine my critic's figures; nor does it seem worth while to do so. My equation (2) represents refractive indices with an accuracy of about four and a half places of decimals, while most of the authorities upon whom he relies only give these quantities to five places of decimals. If this difference of five units in the fifth place of decimals can originate such changes in the focal curve as he supposes, it is evident that trustworthy conclusions can only be reached by using very accurate dispersion formulæ. Cauchy's formula, as written in equation (2), has hitherto been most used; but when compared with the best observations, the residuals, although small, show some constancy of sign. It has recently been claimed* that Briot's formula, which is

$$\mu=a+b\lambda^{-2}+c\lambda^{-4}+k\lambda^{2} \qquad (48)$$

represents the best observations, throughout the whole space from the extreme ultra-red to the extreme ultra-violet, within the limits of accidental error. If such is the case, a triple objective may possibly be better than a double one; but my critic's figures certainly do not suffice to prove this. They are founded upon a formula whose independent variable is not the wave-length of the light, but the refractive index of a standard piece of glass; and his Table II, page 432, shows that when compared with observation this formula yields residuals exhibiting as much constancy of sign, and almost the same magnitude, as those given by my equation (2). The use of any independent variable other than the wave-length, is likely to produce erroneous results, and certainly does not tend to elucidate the subject.

Having seen that a dispersion formula involving only three powers of the wave-length suffices to represent the best observations, and remembering that this circumstance limits the number of lenses which can be employed with advantage in an

* By M. Mouton, in the Comptes Rendus, 1879, vol. lxxxviii, p. 1190.

objective to not more than three; we are now in a position to appreciate the absurdity of my critic's assertion, page 429, when, enquiring if it is possible to eradicate the secondary spectrum by increasing the number of lenses in an objective, he says, "Theoretically, since a new disposable constant for color change is introduced with each lens in the system, the answer is evidently affirmative; * * *"

For an objective consisting of more than two lenses, and a law of dispersion involving more than two powers of the wave-length, the condition given in my former paper, page 196, for the best color correction, is no longer applicable. The problem then becomes very complex, but I am inclined to think that it is satisfactorily solved by attributing to each element of the focal curve a mass proportional to its efficiency for the purpose for which the correction is required, and varying the curve until its moment of inertia about its intersection with the focal plane becomes a minimum. It is also probable that this condition will suffice to determine the relative merits of double and triple objectives; the focal curve with the smallest moment being the best.

Finally, it only remains to reiterate that the conclusions of my former paper are certainly correct to the degree of accuracy involved in my fundamental equations—that is, for a system of infinitely thin lenses in contact, and for the law of dispersion embodied in equation (2). For a different law of dispersion, or if the thicknesses and distances apart of the lenses are considered, these conclusions may require modification.

Washington, Dec. 29, 1879.

ART. XIV.—*Pinite in Eastern Massachusetts: its Origin and Geological Relations;* by W. O. CROSBY.

ONE of the most interesting constituents of the conglomerate so extensively developed in the vicinity of Boston is a soft, greenish and somewhat unctuous, amorphous mineral, which many observers have mistaken for serpentine, but which is shown by its ready fusibility not to be magnesian; while analysis proves that it is essentially a hydrous alkaline silicate of aluminum. In fact, it presents in its chemical, as well as its physical, characters a close agreement with the species pinite. (See analyses below). The hardness is ordinarily near, or a little above, 3; the purer varieties, however, usually refuse to scratch calcite. The specific gravity, so far as determined, is between 2·7 and 2·75. Luster none, or waxy and feebly shining. The predominant color is a whitish-green; but the variation is from nearly white through whitish, grayish and dirty

greens to a dull grass or olive green. The deeper color seems usually to belong to the purer varieties.

At some points, the paste or cement of the conglomerate appears to include much pinite; yet in its purest state this substance occurs mainly in the form of pebbles. In either case, however, it is always clearly an imported constituent of the rock. Although not properly a principal ingredient of the conglomerate, the pinite detritus is scarcely ever entirely wanting; while in several limited localities the rock is mainly composed of it; forming a distinct pinite conglomerate. The following are the principal localities in the Boston basin where the conglomerate is notably rich in pinite: the north shore of Squantum: Milton, on and near Central Avenue; several points in Newton, especially in the vicinity of Newton Corner and Newton Upper Falls; and along the line of the Sudbury River Aqueduct in South Natick.

The pinite pebbles, probably on account of their inferior hardness, being permanently plastic, as it were, are usually very much flattened in parallel planes; giving rise, where they are sufficiently abundant, to a decidedly schistose structure in the rock, or more properly an imperfect cleavage. This cleavage structure in the pinite conglomerate is very clearly the result of pressure, and shows a nearly constant dip and strike in all parts of the district; being entirely independent of the stratification, and agreeing perfectly in all these respects with the cleavage of the slate rocks. Where the pinite pebbles are scattering, they are sometimes found as contorted layers enveloping pebbles of harder materials.

The distinctly stratified rocks of the Boston basin include two principal varieties—the conglomerate, or "Roxbury pudding stone," and the slate. The volume of each of these varies from four hundred or five hundred to perhaps one thousand feet; and the former constitutes the lower half and the latter the upper half of one continuous and conformable series. The upper or argillaceous member of the formation includes the Paradoxides slate in Braintree; and this determines the Primordial age of the entire series. The slate, and more especially the sandstone which marks the passage from the slate to the conglomerate, is sometimes greenish and evidently composed in part of the débris of pinite. The sediments in the basin of the River Parker, some thirty miles northeast of Boston, are also probably of Primordial age; and the conglomerate portions are largely, sometimes almost entirely, composed of pinite. Traces of this mineral have been frequently observed in the conglomerate of uncertain age skirting the southern base of the Blue Hills, and extending thence southwesterly to Rhode Island.

The pinite is also found in other fragmental formations of this region. Underlying the Primordial beds of the Boston and River Parker basins, and having its best development in the towns of Marblehead, Saugus, Melrose, Malden, Medford, Dedham, and Hyde Park, is an extensive and somewhat peculiar conglomerate rock known locally as the "breccia" or "petrosilex breccia," being principally, usually almost wholly, composed of fragments of petrosilex cemented by a paste of the same rock more finely comminuted. The breccia is often of a greenish color, and in not a few localities includes in both fragments and cement large amounts of what appears to be more or less perfect pinite, i. e., material of a light green or greenish-white color, which yields readily to the knife, affords water in the closed tube, and is somewhat unctuous, resembling serpentine in many of its physical characters, and yet easily fusible before the blowpipe. Dr. T. Sterry Hunt has called my attention to the existence of pinite in the breccia in Saugus; and my own observations have convinced me that its occurrence in this way is a general fact. The best points for observing this variety of breccia are the following: East Saugus, south of the railroad; Newton, about one mile south by west from Newton Center; West Dedham; many points in Hyde Park and the adjacent part of Dorchester (Mattapan); and Milton, between the Neponset River and Pine Tree Brook.

The basins mentioned as holding the Primordial strata and the underlying breccia have been excavated from the ancient Huronian formation, which, in Eastern Massachusetts, consists mainly of the following lithological members: granite, binary and hornblendic; petrosilex, stratified and unstratified; stratified and unstratified diorite; and quartzite. In these old crystalline rocks we have the sources of all the materials observed in the conglomerate and breccia, not excepting the pinite. In this connection, the most interesting Huronian terrane is the petrosilex. For the sake of convenience, I here include under the name petrosilex both the acidic division of the compact feldspar rocks, or petrosilex proper, and the basic division, or true felsite. The physical distinctions between the true petrosilex and felsite, in Eastern Massachusetts, are not conspicuous. They both include exotic and indigenous varieties; and both present the same general range in textures, including, besides the ordinary compact and porphyritic forms, many different kinds of banded structure. Elvanite or quartz porphyry is a common rock; but this belongs, of course, entirely to the acidic group. As a result of numerous chemical analyses, I find that the petrosilex predominates, and is usually of red, brown or purplish tints; while the characteristic colors of the felsite are greenish, whitish and sometimes black.

Although associated with both the petrosilex and felsite, the pinite is found most frequently with the latter. Wherever occurring in the conglomerate and breccia, as already observed, this material is always clearly an imported constituent; but with the Huronian formation it never presents this aspect, all the facts pointing to the conclusion that it is indigenous here. In other words, and more explicitly, the pinite, as far as the evidence allows us to judge, exists in the Huronian series only in association with the petrosiliceous group, and here only as a product of the superficial decomposition or alteration of these rocks. Indications of this may be observed in many places. In the first place, we have abundant evidence in the fragmental rocks themselves that the pinite which they contain has been derived from, and owes its genesis to the alteration of, the Huronian petrosilex (using this term in its comprehensive sense, as explained above); for there exists, both in the pebbles of the puddingstone and the fragments of the breccia, every possible gradation between unaltered petrosilex and the purest pinite; and it seems highly probable that much of the petrosiliceous débris of these rocks is still suffering some change in the direction of a conversion to pinite.

Turning now to the parent formation, we find the evidence even more conclusive. For instance, the greenish elvanite which covers a large area in Needham, usually presents a slaty appearance, yields to the knife, and affords water abundantly. Substantially the same statement may be repeated concerning the green petrosilex in West Dedham, and the greenish "toadstone" and some other varieties of petrosilex in Newbury. In all these cases the rock is green, at least superficially. In Marblehead, Lynn, and other districts, I have observed the brown, gray, black, and other colors of the petrosilex changing to green near the joints. In many instances, probably, the change is to kaolinite rather than pinite, but not always.

Another argument showing the derivation of the pinite in the fragmental rocks from the petrosilex is found in the fact that, with few exceptions, those portions of the conglomerate (and the same is true of the breccia), marked by a predominance of pinite débris occur in close proximity to ledges of petrosilex; and in the exceptional cases the underlying rocks are probably petro-siliceous. This association is very significant; but the strongest evidence on all these points yet remains to be adduced.

The locality affording at once the clearest proof that the pinite is indigenous in the petrosilex, that it makes its appearance in this association as a decomposition product, and that pinite so originating is essentially identical with, and the source of, that in the more recent, detrital formations of Eastern Mas-

sachusetts, is in Milton, on Central Avenue, about one-fourth mile south of the Neponset River. The petrosilex is exposed here only on the northwest side of the avenue, forming the southwest end of a section which is composed mainly of a typical example of pinite conglomerate. The small pinite pebbles are embedded in a brownish, slaty paste, and have suffered an extraordinary degree of compression, developing a well-marked foliation or cleavage in the rock. The contact between the petrosilex and conglomerate is straight and well-defined. It strikes east-west, and dips to the north 75°, being exactly parallel with the schistosity or cleavage of the last named rock; while this imperfect cleavage agrees perfectly in dip and strike with that observed elsewhere among the slates and conglomerates of the Boston basin. The contact just noticed almost certainly marks a fault, and both it and the cleavage are at right angles to the strike of the beds. The stratification, however, is much obscured by the cleavage, though it can still be made out by careful observation.

The color of the unaltered petrosilex in this case is dark purple, and the pea-green pinite occurs in it in the form of irregular and ill-defined masses which seem to have their major axes normal to the surface of the ledge. Closer observation shows that they follow the jointing of the petrosilex; each joint being bordered on either side by pinite which exhibits a *gradual* passage into normal petrosilex at a distance of a few inches. The rather limited exposure is best in the vertical direction; and tracing one of the pinite-bordered joints downward, it seems plain that the zone of this material is broadest and best-marked near the surface, becoming narrower below, and almost entirely fading out at a depth of a few feet. The best examples of the pinite are found along those joints which have become the seats of slender veins of quartz. The disposition of the pinite in the petrosilex evidently leaves us no option but to believe that here at least it is a decomposition-product; and that percolating atmospheric water, for which the joints have afforded channels, has been the chief agent in its formation.

The indications are very strong that, geologically speaking, the conglomerate has not been long removed from this part of the petrosilex; hence this is probably, in all essential respects, an ancient surface; and I take it that we have here an example of pre-Primordial decomposition. The composition of a characteristic specimen of the pinite, taken from its original position in this ledge, is shown by the following analysis (I), made by Miss E. M. Walton:—

	I.	II.
SiO_2	57·924	59·520
Al_2O_3	23·739	21·628
FeO	2·826	5·840
K_2O	4·560	6·900
Na_2O	5·283	·804
H_2O	3·142	3·490
MnO	1·443	not det.
Cr and Mg	traces	not det.
	98·917	98·182

e pinite in this petrosilex is unquestionably the source of with which the overlying slaty and schistose conglomerate replete. For, first, the pinite in the conglomerate dimin rapidly as we recede from the outcrops of petrosilex; and, dly, the mineral, in the two geological positions, is essen identical physically and chemically. The pinite pebbles ıostly quite small and well flattened; and hence consider samples are not easily secured. The portion submitted to sis was obtained from perhaps a dozen pebbles from dif t parts of the ledge, great care being taken to prevent xture with the slaty paste. This was analyzed by Mrs. B. Crosby, and the result is given in analysis II above.*

e formation of pinite by the alteration, and particularly ıe hydration, of feldspathic rocks and minerals, which has denied by some authorities, must apparently be conceded me cases. Of course where derived from a rock holding quartz in an impalpable state, such as petrosilex, the pinite, gh appearing quite pure, may, as the above analyses show, l an abnormally high percentage of silica. A typical ple of purple banded petrosilex from the Milton area, gh not from the pinite ledge, afforded 66·3 per cent of . This is, strictly speaking, essentially a true felsite. r ledges in the vicinity of Central Avenue contain an dance of pinite, but the exposures are not favorable for aying its relations to the felsite.

summarizing the geological history of the pinite (or pinite t, since, considering its origin, it is rather more properly a than a mineral), we may say that, to furnish the pinite ;us of the various fragmental rocks in Eastern Massachu an extensive formation has been required. No vestiges ıch a formation, distinct from the Huronian petrosilex, exist in this region; and with the petrosilex we have the e only as a product of superficial decomposition. The seem to warrant, or at least to forcibly suggest, the con-

*th of these analyses were made in the Woman's Laboratory of the Massa-ts Institute of Technology.

clusion that, in pre-Primordial times, the petro-siliceous rocks, to a considerable depth, were changed by the action of atmospheric agents, not to kaolin, as generally at the present time, but to or toward pinite; and that subsequently this decomposition-product was, for the most part, swept away by the sea in which were deposited the breccia and the Primordial conglomerate.

Another very clear example of the derivation of pinite from feldspar has been observed on the rocky peninsula of Marblehead Neck. On the northwest shore of the Neck, visible only at low tide, is a hard, whitish, compact, feldspathic sandstone or slate, the age of which is unknown. It rests unconformably upon the banded petrosilex forming the shore at this point; and the layer of pebbles at its base shows very clearly that the sandstone is chiefly composed of the débris of the petrosilex. This origin explains the highly feldspathic nature of the sandstone. Scattered through the sandstone are clear, almost transparent, rhombic crystals of orthoclase, 3 to 6^{mm} long, which are very clearly indigenous in their present positions. Occasionally they are sufficiently numerous to give a porphyritic aspect to the rock. Erratics of this sandstone are scattered all over the Neck; and in some of these which are very thoroughly weathered, the orthoclase crystals are changed to a soft, unctuous, waxy, green mineral,—in other words, to pinite. Where the weathering has been less thorough, the characters of the pinite are less strongly marked.

ART. XV.—*On Lintonite and other forms of Thomsonite: A preliminary notice of the Zeolites of the vicinity of Grand Marais, Cook County, Minnesota;* by S. F. PECKHAM and C. W. HALL.

GRAND MARAIS is situated on the northwest coast of Lake Superior, one hundred and eight miles northeast of Duluth. It is the site of an early French trading or mission station, and was later a station of the Hudson Bay Company. Its beautiful land-locked bay furnishes the only good harbor between Duluth and Pigeon Point.

The rocks, for several miles east and west, as well as at the Marais, are classed in general as igneous, and have often a basaltic structure. They present, however, great diversities of character both to the chemist and lithologist; and while the mineral species are perhaps altogether old, the forms are in some cases new. It was our original intention to confine this research to one or two peculiar forms that first attracted our attention, but in the progress of our examination the subject has outgrown its

earlier proportions, both as regards its extent and the time required for its successful completion. We have therefore concluded to give in the present paper some general observations with such details as are at present in hand, reserving others until further study and analyses shall have rendered the work more complete.

At Good Harbor Bay, about four miles to the westward of Grand Marais, there begins a bed of dark colored rock, highly decomposed at surface, and related to diabase in its lithological characters. This bed extends westward along the coast for several miles, sloping gently from the wooded hilltops a mile or two inland, and disappearing beneath the waters of the lake. In its fresher parts the rock is somewhat mottled where coarsest, and nearly black with a greenish tinge where finest in texture. It is only from the talus, under the wall of rock rising above an underlying sandstone outcrop in Good Harbor Bay, that this fresh material can be easily obtained. Even here the mottled appearance discloses the partial decomposition of the most perishable of the constituents, and the formation of some new viriditic mineral. The lower layers are firm and compact, while the upper are extensively jointed and fractured, and filled with amygdaloidal cavities. These cavities, in whatever manner they were originally formed, have become filled with zeolitic minerals. Some of the cavities are now empty, but evidently as a result of the removal of their contents by solvents percolating through the enclosing rock. Occasionally the cavities are only partially filled, and the substance within shows on its surface unmistakable traces of the action of solvents. In some cavities one mineral is nearly all washed away, leaving the surface of the remaining one or several, as the case may be, rough or uneven, as originally formed. This occurs only where water has had access.

The prevailing mineral, thomsonite, is only sparsely distributed in the lower and compacter beds of the formation. The general occurrence of the several other minerals, so abundant here, would seem to indicate that this mineral was formed first of all from the decomposition of the rock, and that one of the others owes its origin in part at least to the decomposition of those that were formed before it. In many masses of the rock where much exposed and weathered the matrix has been so decomposed as to be easily broken away from the amygdules, but in the fresher portions the fractures extend across them. The other zeolites, being less persistent than the thomsonite, rapidly disappear, while the amygdules of this mineral remain upon the narrow beaches of this vicinity in the form of pebbles of various sizes frequently unbroken and beautifully polished.

The cavities containing thomsonite are in many places ex-

ceedingly numerous, and in other cases few in number, even in the same bed of rock. The size varies from a microscopic point to a diameter of two or three inches. In one piece of the thomsonite-bearing rock, now in the General Museum of the University of Minnesota, the number of amygdules distinctly visible to the unaided eye on a surface two inches square is sufficient to give more than 10,000,000 to the cubic foot. The largest in this area was about half an inch in diameter. The amygdules are generally much larger and more scattered than this specimen would indicate. Since they abound in the rock throughout many feet of its thickness and many miles of its extent along the shore, the supply appears to be inexhaustible; but practically the number of beach-pebbles, valuable as specimens, is quite limited. All the different varieties of thomsonite are so hard that they take a fine polish; and on account of this property and their often unique banded structure, they are much sought after by tourists and others as objects of rare beauty, and also for buttons, studs, etc.

On our first visit to the beach where the greater number of these pebbles occur, we at once recognized fragments of the large amygdules as thomsonite. Intermingled with these were spherical and oval pebbles, often more or less flattened, and of all sizes from that of a pin's head to that of a hickory nut, but for the most part of the size and form of beans and peas. Some of these were also recognized as thomsonite. The larger portion presented a great diversity of color and physical structure; some being white and opaque, almost conchoidal in fracture, with but slight indications of a fibrous structure; others flesh-colored throughout, hard and fibrous, resembling thomsonite from the Tyrol and other localities except in their greater hardness and finer texture; others coarser, closely resembling the mineral from other localities; others, curiously banded externally with zones and annular spaces of red, green, pink and white; and still others, opaque and chrome-green in color, shading out in some to colorless and translucent with a con choidal or uneven fracture. These last were at first supposed to be fragments of prehnite, rounded by attrition. On further examination a number of the green pebbles were found to have a fibrous and flesh-colored interior with a shell of the amorphous green mineral. In given portions of the rock formation, the amygdules were, for the most part, of the same general character; in one place, being green and opaque; in another, without green bands; while in another, for the most part, beautifully variegated. Similar local peculiarities were observed in reference to texture, some portions of the rock containing only those that were hard and fine grained, while others those that were uniformly coarser in texture.

In our examinations of the amygdules, we designated the opaque white variety, Number *one* (I), the ordinary thomsonite, Number *two* (II), and the *green* varieties, Number *three* (III).

As regards hardness, the thomsonite—in nearly all its varieties—is peculiar. Some fibers scratch quartz, which indicates a hardness above 7; but this may be owing to the presence of free silica. The harder specimens of No. III scratched an agate mortar easily, but were scratched by quartz crystal; yet the percentage of silica was found to be no higher in the harder than the other specimens. The grain of such specimens, however, is exceedingly fine. Most frequently the hardness is between 5 and 6. The specific gravity varies from 2·33 to 2·35; the water-worn and somewhat weathered pebbles have it a little lower, one or two as low as 2·2. The fracture of Numbers I and II is fibrous; of Number III very uneven, and takes place in all directions with almost equal facility. They all gelatinize in hydrochloric acid to a thick jelly. Before the blowpipe they fuse easily and intumesce to a porous white enamel. In the closed tube, water to the amount of 11 to 12 per cent of the whole weight was given off at the heat of an ordinary spirit lamp. Grains of native copper are frequently found in them, particularly in those of Number III, which, if the pebbles are transparent, exhibit under a low magnifying power arborescent groups of crystals, thrusting out their branches in every direction through the enclosing mineral. In one instance an amygdule, about as large as a cranberry, contained at its center a mass of copper of this kind, one-third of its diameter. In this characteristic Number III resembles the prehnite of French River.

Number I.—The amygdules of this type are perhaps of less common occurrence than other forms. Externally they look like porcelain with a slight creamy tint. Under the microscope they appear for the most part translucent. Countless fine dark lines extend longitudinally through the thin section, rapidly disappearing to be replaced by others, like the cells in a longitudinal section of wood, which are probably caused in part by refraction of the light from the edges of minute densely packed crystals, from cavities, and from microlites. One noticeable result of these lines is to weaken the effect of the mineral on polarized light. Not infrequently this opaque modification of the mineral is banded with alternating zones, either transparent or yellow, or even with both; the transparency here seems to be owing to an absence of the lines and microlites just noticed; while the yellow zones owe their color to globules of ferric oxide distributed through the mass. In the worn amygdules the mineral often has a beautiful pearly luster. In minute quantities the ferric oxide gives the mineral a flesh-colored tint.

A mean of three analyses showed the composition of mineral to be:

SiO_2	40·45
Al_2O_3	29·50
Fe_2O_3	0·232
CaO	10·75
K_2O	0·357
Na_2O	4·766
H_2O	13·93
	99·985

Even opaque *white* amygdules afforded a trace of ferric o which increased to a few hundredths of one per cent when tint was perceptibly flesh-red.

Number II.—Under this type nearly every specimen is fib and radiated. The masses are spherical or elliptical, with point from which the crystalline fibers radiate on. one sid the mass, or, as is perhaps more common, having several ters of radiation within the compact mass. Occasionally mineral fills seams, or occupies cavities that run toget here, there are centers of radiation at frequent intervals an a system of suture-like joints, the whole is made into a pact mass. Yet, solid as the mass may appear to be, a thin cut from it invariably separates into pieces along the lin these joints, giving the mineral an appearance of fragility w it is really as hard as agate. The fibers often interlock a the line of these joints.

At the outer extremity of many of these radiated concreti there often occur many transparent needles, large enough t seen with the unaided eye, extending backward along the rection of the fibers toward the center of radiation. T needles are broken up into short pieces by transverse fract They all taper out and disappear, the longest of them reac no further than the middle of the mass. They act strongly polarized light and contain some inclusions. These lines not occur as developed crystals.

Around the borders of many amygdules there are nume small sphærolites. They have probably formed around g ules of various foreign substances as nuclei. Their size is sm to the naked eye they look like mere spots, but they ar numerous as to form an envelop almost entirely around radiated concretions.

A mean of three analyses gave—

SiO_2	46·020
Al_2O_3	26·717
Fe_2O_3	0·813
CaO	9·400
K_2O	0·390
Na_2O	3·756
H_2O	12·800
	99·896

Number III.—As before stated these pebbles, when first seen, were supposed by us to be worn fragments of reniform prehnite, so common in several localities along this shore. We soon found evidence that they were amygdules; still the fact that they were not prehnite was not suspected until their specific gravity had been determined and found to be that of thomsonite, 2·32 to 2·37. Analysis showed them to contain—

SiO_2	40·605
Al_2O_3	30·215
FeO	·40
CaO	10·370
K_2O	·49
Na_2O	4·055
H_2O	13·75
	99·885

This composition allies the mineral very closely to thomsonite, so closely that, considered alone, there appears little reason why the mineral should not be considered as a variety; but there are several notable reasons why a specific name may properly be applied to this, as we believe, hitherto undescribed mineral.

These pebbles are wholly destitute of the radiated and crystalline character of other forms of thomsonite. Under the microscope the texture is wholly granular so that the crystalline system cannot be determined; and the granules are so fine and so compactly arranged in many specimens that they can be resolved only in polarized light. Their size, however, is not uniform in the same pebble, being so fine in some places that only a high power will make them visible.

Sphærolites are also frequent; but unlike their mode of occurrence in the thomsonites, they are distributed almost at random in any part of the amygdules containing them; and frequently some foreign material, as a bit of copper, is a nucleus. The sphærolites often occur in groups; large numbers are crowded and heaped together, growing into and overlapping one another, like the tridymite scales in the rhyolites of Mexico and the trachytes of the Siebengebirge. These groupings are not always spherical; sometimes they extend in long curving lines through the mass, following perhaps a fracture or

a seam, instead of being collected around a nucleus as a sphærolite. They show parallel green fibers meeting along a median suture and correspond in their manner of occurrence to Zirkel's description of axiolites in the rhyolites of the 40th parallel.*

The amygdules of the green variety rarely exceed in size a small hickory nut. As before stated, they are not generally found intermingled in the rock with the other forms, but have special localities—they filling nearly all the amygdaloidal cavities within a given limit, whose boundary at the same time is not sharply defined. Frequently the forms of Number I or II are enveloped in a green covering of considerable thickness. Moreover, the amygdules of this type uniformly contain ferrous oxide in small but varying proportion in combination, whereas in Numbers I and II the microscopic sections show the ferric oxide to be segregated in minute particles or patches mechanically distributed through the fibrous mass; and in many amygdules these particles can be seen distinctly even with the unaided eye. Nor can Numbers I and II be considered as altered forms of Number III, as the condition of the iron might indicate. No amygdule has come under our observation which exhibited a nucleus of Number III, surrounded by Number I or II. On the contrary, we have quite a number in which, through a thin translucent shell of Number III, the pink interior can be discerned. And we also have fragments, and amygdules have been cut, which show the external crust of Number III passing toward the center into the radiated form of Number II.

In determining the oxygen ratio for Number II, the silica appeared to be too high. We had previously suspected the presence of free silica from the exceptional hardness of all of these varieties. As the microscope showed the ferric oxide in every case to be free, we concluded to compute the percentages for Number II to 40·45 per cent of silica, the amount found in Number I, and exclude the iron oxides. We were much surprised at the results, which are given below:

	I.	II.	III.
SiO_2	40·45	40·45	40·605
Al_2O_3	29·50	29·37	30·215
CaO	10·75	10·43	10·37
K_2O	0·36	0·42	0·49
Na_2O	4·76	4·28	4·05
H_2O	13·93	13·93	13·75
	99·75	98·88	99·48
Fe_2O_3	0·23	0·88	FeO ·40
	99·98 pr. ct.	99·76 pr. ct.	99·88 pr. ct.

* U. S. Geol. Explor. 40th Parallel, vol. vi, p. 166 et seq.

These figures prove conclusively that we were dealing with varieties of the same mineral. On comparing these percentages with those given in Dana,* the water and silica were found to be high.

Computing the oxygen ratios and formula for Number III, we have

	Per cent.	Metal.	Oxygen.	Atoms.
FeO	0·40	0·3111	0·0889	·0064
K_2O	0·49	0·4068	0·0832	·0052
Na_2O	4·055	3·0118	1·0432	·0654
CaO	10·37	7·4070	2·9630	·1852
			4·1783 R.	·2622
Al_2O_3	30·215	16·1343	14·0807	·2933
SiO_2	40·605	18·949	21 656	·676
H_2O	13·75	1·528	12·222	·765

Dividing the oxygen percentages by 5, we have

$$RO : R_2O_3 : SiO_2 : H_2O = 1 : 3 : 4 : 2\tfrac{1}{2},$$

which is the ratio for thomsonite, given in Dana's Mineralogy, with the bases low and the silica and water high. Dividing the atoms by ·005 we have the formula

$$(\tfrac{2}{5}(FeO+K_2O+Na_2O)+\tfrac{3}{5}CaO)Al_2O_3,\ (SiO_2)_2(H_2O)_3,$$

with the protoxide bases low, and the silica and water high.†

Computing the ratios after Rammelsberg, we have:

(Na+K) : (Ca+Fe) : : 1 : 1·35
(Ca+Fe) : Ⱥl : : 1 : 1·54
(Ca+Fe+K+Na)=R : Ⱥl : Si : : 1·13 : 1 : 2·03
Si : H : : 1 : 2·26

Rammelsberg deduces from these ratios a formula which he calls a half silicate (Halbsilicat), according to the expression

$$\left\{ \begin{array}{l} m(2\text{Ca Ⱥl}Si_2O_8+5aq) \\ n(2Na_2\text{Ⱥl}Si_2O_8+5aq) \end{array} \right\} ‡$$

in which m indicates a certain proportion of a hydrous silicate of aluminum and a dyad protoxide, and n a certain proportion of a hydrous silicate of aluminum and an alkaline or monad protoxide. The ratio between m and n varies in different specimens. Number I and Number II, without the excess of silica, approach more nearly the thomsonite of Elbogen in composition (in which the ratio of m to n=2 : 1) than any mentioned by Rammelsberg. While the ratio of Si to H is about the same as given by Rammelsberg, the percentage of both in these specimens is higher than in the analyses quoted by him.

* System of Mineralogy, fifth edition, p. 425.

† 5th ed., p. 425.

‡ Rammelsberg Min. Chem., Ed. 1875, p. 637.

We conclude, therefore, that this mineral contains a small percentage of free silica, and also that a part of the water is basic. This latter opinion is strengthened by the fact that about 12 per cent of the water escaped at a dull red heat, and that only prolonged heating in a platinum crucible for several hours would expel the last 1·75 per cent. At least six determinations of the water were made in this variety, with the same result.

The percentages of Numbers I and II are so near that of Number III that no material difference can exist in their formulæ. While recognizing this fact as respects the chemical constitution of these minerals, the great difference in their physical structure leads us to regard Number III as a distinct and well marked variety of thomsonite, if not a distinct species. We have therefore given it the name *Lintonite*, in honor of Miss Laura A. Linton, a recent student and graduate of this University, to whose patient effort and skill we are indebted for the analyses given in this paper.

University of Minnesota, Nov. 20, 1879.

ART. XVI.—*Elements of the Planet Dido*; by Professor C. H. F. PETERS. (From a communication to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., January 4, 1880.)

FOR the planet *Dido* (209), I have derived from observations of October 25, November 15 and December 7, the following elements:

Epoch: 1880, January 0·0, Berlin m. t.

$$\begin{aligned} M &= 201^\circ\ 56'\ 40''\cdot 3 \\ \pi &= 196\ \ 41\ \ 13\cdot 6 \\ \Omega &= 1\ \ 21\ \ 41\cdot 3 \\ i &= 7\ \ 3\ \ 9\cdot 0 \\ \phi &= 1\ \ 18\ \ 38\cdot 3 \\ \mu &= 629''\cdot 122 \\ \log a &= 0\cdot 500848, \end{aligned}$$

which represent an observation obtained on January 1, when it was still very near. The small eccentricity of the orbit is remarkable. In consequence of this, there remains considerable uncertainty as to the longitude of perihelion and the mean anomaly, but not as to their sum $M+\pi=L$, the mean longitude in orbit.

ART. XVII.—*Analyses of some American Tantalates;* by W. J. COMSTOCK. (Contributions from the Laboratory of the Sheffield Scientific School, No. LVII.)

THE following paper contains analyses of three American tantalates which have not been previously investigated, and which offer some points of especial interest.

No. I was collected by the late Professor F. H. Bradley, in Yancey county, N. C.; its precise locality is unknown. The specimen analyzed was from a massive piece, a few ounces in weight. Specific gravity = 6·88.

	I.	II.	Mean.	Ratios.	
Ta_2O_5	60·50	59·35	59·92	·1349	·2231
Nb_2O_5	23·02	24·24	23·63	·0882	
FeO	12·90	12·82	12·86	·1786	·2302
MnO	3·09	3·03	3·06	·0431	
MgO	0·35	0·32	0·34	·0085	
Total	99·86	99·76	99·81		

$R_2O_5 : RO = 1 : 1·03$ and $Nb_2O_5 : Ta_2O_5 = 1 : 1·53$ or nearly $2 : 3$.

No. II was from Northfield, Mass. The portion analyzed was a fragment of a large crystal, which had the habit and angles of ordinary columbite. It was placed in my hands by Professor Brush. Specific gravity = 6·84.

	I.	II.	Mean.	Ratios.	
Ta_2O_5	57·23	56·57	56·90	·1281	·2281
Nb_2O_5	26·62	27·01	26·81	·1000	
FeO	10·11	9·98	10·05	·1397	·2225
MnO	5·92	5·85	5·88	·0828	
Total,	99·88	99·41	99·64		

$R_2O_5 : RO = 1·025 : 1$ and $Nb_2O_5 : Ta_2O_5 = 4 : 5·1$.

No. III was from Branchville, Conn. Its occurrence was described by Messrs. Brush and Dana,* and the specimen analyzed was given to me by them. Only a small quantity of the mineral was found at the locality, and enough for one analysis was all that could be obtained pure. Its powder was brownish-gray, and in thin fragments it was slightly translucent. Specific gravity = 6·59.

		Ratios.	
Ta_2O_5	52·29	·1175	·2301
Nb_2O_5	30·16	·1126	
MnO	15·58	·2194	·2319
FeO	0·43	·0059	
CaO	0·37	·0066	
Total,	98·83		

$R_2O_5 : RO = 1 : 1·007$ and $Nb_2O_5 : Ta_2O_5 = 1 : 1·04$.

Tantalic and niobic acids were separated by Marignac's method,† in the application of which I have received all neces-

* This Journal, July, 1878, p. 34. The specific gravity, by a typographical error, as I am informed, is there given 5·6 instead of 6·5.

† Archives des Sci. *Phys. et Nat., Jan., 1866.*

sary aid from Professor O. D. Allen. In other respects the methods recommended by H. Rose were followed. The ordinary methods of testing for and separating tin, tungsten and titanium were applied in each case, with negative results.

The relation between the specific gravities of columbites and tantalites and the percentage of tantalic acid, shown by Marignac, holds good in these examples also, as will be seen by a comparison with the numbers given in Marignac's table.*

			Sp. gr.	Ta_2O_5.
1.	Columbite,	Greenland,	5·36	3·3 %
2.	"	Acworth, N. H.,	5·65	15·8
3.	"	La Valate, near Limoges,	5·70	13·8
4.	"	Bodenmais, (*Dianite*),	5·74	13·4
5.	"	Haddam, Conn.,	5·85	10·(?)
6.	"	Bodenmais,	5·92	27·1
7.	"	Haddam,	6·05	30·4
8.	"	Bodenmais,	6·06	35·4
9.	"	Haddam,	6·13	31·5
10.	Tantalite,		7·03	65·6

To which are here added—

	Sp. gr.	Ta_2O_5.
Yancey Co, N. C.,	6·88	59·92
Northfield, Mass.,	6·84	56·90
Branchville, Conn.,	6·59	52·29

These all agree with the formula $(Fe,Mn)(Ta,Nb)_2O_6$.

Since tantalum and niobium appear capable of replacing each other in all proportions in columbites and tantalites, Rammelsberg† has suggested that when the number of tantalum atoms exceeds that of the niobium atoms, the mineral should be called tantalite, and when the number of niobium atoms exceeds that of the tantalum, the mineral should be called columbite (Rammelsberg uses *niobite*). According to this method of classification, the Yancey county and Northfield minerals would be called tantalite, although the latter in form is not to be distinguished from columbite. The manganese niobo-tantalate from Branchville, however, has the ratio $Nb : Ta = 1 : 1$ (very nearly), a coincidence which we might reasonably have supposed possible. The almost complete displacement of iron by manganese is also an interesting peculiarity of the Branchville mineral, and is doubtless the cause of its slight translucency and the light color of its powder.

It is perhaps of interest to add here that a mineral of this group from Utö, Sweden, containing 85·5 per cent of tantalic and niobic acids and 9·5 per cent of manganese protoxide (3·6 FeO), has been called *mangantantalite* by Nordenskiöld.‡

* Given in his paper first referred to, in which he explains the variations from a regular progression, which are seen in the table.

† Mineral Chemie, 2d edition, 1875, p. 356. ‡ Zeitsch. Kryst., i, p. 386, 1877.

Art. XVIII.—*On a Method of Studying the Reflexion of Sound-Waves;* by O. N. Rood, Professor of Physics in Columbia College.

It has been the custom for several years to introduce in certain forms of the melodeon a revolving fan for the purpose of obtaining rapid alternations in the intensity of the notes. This arrangement is called a "tremolo," and its action was considered by its inventor and by those interested in it to depend on the currents of air produced by the motion of the fan. An examination of the apparatus soon convinced me that this idea was erroneous, and that the alternations in the loudness of the sound was due to reflexion or non-reflexion from the face of the revolving fan, for I found that the same effects could be produced by the aid of a circular disc consisting of open and closed sectors and revolving in its own plane. A disc of this kind constitutes a useful piece of apparatus for studying the reflexion of sound-waves, and some results obtained with it were communicated by me to the National Academy of Sciences, as long ago as October, 1876.

As no account of these experiments has ever been published, a short description of them may not be without interest to those engaged in experimental researches on sound, as with their aid the following facts may be easily demonstrated:

1*st. At a perpendicular incidence the short sound-waves are more copiously reflected than those that are longer, and the regular reflexion is more copious from large than from small surfaces.*

The diameter of the zinc disc was in the first set of experiments 21 inches =53·3 centimeters; alternate quadrants were removed, and the rate of rotation varied from two to four turns in a second. The tuning-forks were mounted on their resonance boxes and gradually removed away from the revolving disc till the alternations could no longer be distinguished by the ear placed near the fork. The results are given in the table below, in which "distance" indicates that of the open end of the tuning-fork from the disc:

Diameter of disc	21	inches.	
Ut_3 fork; alternations heard at	13	"	distance.
Ut_4 " " "	20	"	"
Ut_5 " " "	96	"	"

When the same experiments were made with a disc having a diameter of only 8½ inches or 21·5 centimeters, it was found necessary to bring the forks much nearer to the disc before the alternations could be perceived.

Diameter of disc		8½	inches.	
Ut_3 fork;	alternations heard at	2	"	distance.
Ut_4 "	" "	3	"	"
Ut_5 "	" "	6	"	"

2d. When the sound-waves fall upon small flat surfaces at an acute angle, the reflexion is most copious in the same direction as with light, but the reflected and inflected waves can be traced all around the semicircle.

Experiments on this point were made in the open air, the larger disc being used with angles of 60° and 70° (from the perpendicular); the Ut_4 and Ut_5 forks were employed.

The regularly reflected waves could be heard at a distance of ten or twenty feet from the disc, the fork being held a foot or two from it; inflected waves were easily distinguishable all around the disc and even a few feet *behind* the fork.

When the forks were placed in the plane of the disc the alternations of loudness were reduced to a minimum, but in the open air and in a room never wholly disappeared. This I suppose to be owing to the fact that the source of sound is not a point but a surface. Even under these circumstances, feeble alternations were heard all around the disc, the inflected waves actually returning to their source. With a plain disc alternations were not perceived.

3d. Qualitative comparisons between the power of different substances to reflect sound can easily be made.

For example, a disc of card-board in which filter paper is fastened over the open sectors gives alternations, owing to the difference of the reflective powers of the two substances.

4th. If a composite sound-wave falls on the rotating disc the shorter waves will undergo regular reflexion more copiously than the other components.

This experiment is most easily made with a reed without its pipe. Ut_3, Ut_4, Ut_5 reeds give alternations but mainly in their high overtones; the alternations consequently have a ringing metallic sound.

5th. The reflexion of sound from very small surfaces is easily demonstrated.

If an Ut_3 or Ut_4 reed without its pipe be employed, alternations are easily obtained by moving a visiting card properly near the reed. By substituting a gas-flame for the card the reflexion from the flame can be demonstrated. The gas-burner should be attached to a long slender rod.

Almost all of these experiments are so easily performed as to be suitable for lecture-room purposes.

ART. XIX.—*On Newton's use of the term Indigo with reference to a Color of the Spectrum;* by Professor O. N. ROOD, of Columbia College.

THE coloring matter known as indigo has a dingy, dark blue color, which scarcely qualifies it to rank as a representative of one of the pure brilliant colors of the spectrum. Von Bezold has already objected to its use on account of the *darkness* of the tint, but in the present paper I propose to show that in another and more important respect it is equally inapplicable. Newton intended to designate by it the color of that part of the spectrum which is situated between the blue and violet; indigo, however, is really a representative, though a poor one, of an entirely different region of the spectrum, as will be shown by the following considerations.

Experiments were first made with three different samples of indigo in order to see whether important differences in hue existed when the substance was prepared by different persons. One of the best methods of studying the hue of a colored surface is to ascertain the nature and amount of the colored light which is complementary to it. Discs of card board were accordingly painted with indigo as a water-color pigment and these were combined by Maxwell's method with two discs painted with chrome yellow and vermilion, and neutralization effected by rapid rotation.

Indigo as a water-color pigment (prepared by Winsor and Newton).

Ratio of red and yellow necessary to neutralize it.

Chrome-yellow, 67. Vermilion, 33.

Indigo as a water-color pigment (prepared by Barnard).

Chrome-yellow, 65. Vermilion, 35.

Dry commercial indigo was then rubbed on white drawing paper, and gave a result similar to those just detailed; the ratio was:

Chrome-yellow, 62. Vermilion, 38.

In the dry state the color was then a little more greenish, a slightly larger quantity of the vermilion being required; the three experiments, however, substantially agree.

A solution of commercial indigo in water was also compared with the discs, and seemed to agree well with them.

Instead of comparing one of the dingy indigo discs directly with the brilliant-colored spaces of the spectrum, I made an accurate comparison of its color with that of a disc painted with Prussian blue, reserving the latter for direct comparison with the spectrum.

The Winsor and Newton disc which the previous experiment had proved to be the least greenish in hue, was now combined with one of vermilion and emerald green, and the following equation obtained:

I 51·4+V 29+G 19·6 =32·8 white. A disc of Prussian blue similarly treated gave P.b. 39·9+V 35·7+G 24·4 =27·4 white.

These equations prove that the *hue* of the indigo and Prussian blue discs were identical, for the ratio of the red and green required to effect neutralization is the same, being in the case of the indigo, 59·7 vermilion to 40·3 emerald green; in that of the Prussian blue, 59·4 vermilion to 40·6 emerald green.

The position of the Prussian blue disc in the normal spectrum was now determined with the aid of a large spectrometer, the eye-piece being provided with a slit which excluded all except a narrow slice of the spectrum. Such determinations can be made by a practiced eye with considerable certainty, as I propose to show at some future time. It was found that in a normal spectrum including from A to H 1000 parts the position of Prussian blue was at a distance from A equal to 740 of these parts. Now according to my observations on this spectrum, blue-green ends and cyan-blue begins at 698; also cyan-blue ends and blue begins at 749; hence the color of Prussian blue falls in the cyan-blue space near the beginning of the blue, and to this same position we must consequently refer the color of indigo.

It afterwards occurred to me that possibly Newton might have used the indigo in the dry lump, and accordingly I prepared a flat surface of dry commercial indigo and compared it carefully with the blue furnished by genuine and artificial ultramarine, its color being of course enormously darker, or one might say, blacker than that of either of these substances. A mixture by rotation of six parts of artificial ultramarine blue with two parts white and ninety-two parts black gives a color more or less like that of commercial indigo in the dry cake: that is to say, if a freshly *fractured* surface of indigo be compared with the compound disc just mentioned, the color of the indigo will be found somewhat too greenish; but on the other hand, if a *scraped* surface of the dry cake is used it will be too purplish. Newton therefore probably employed his indigo in the dry state.

I give below, according to my determinations, the positions and corresponding wave-lengths of indigo, Prussian blue, cobalt-blue, genuine ultramarine-blue and artificial ultramarine-blue, in a normal spectrum having from A to H 1000 parts.

	Position in normal spectrum.	Wave-length in $\frac{1}{10000000}$mm.
Indigo, Prussian blue,	740	4899
Cobalt-blue,	770	4790
Ultramarine (genuine),	785	4735
Ultramarine (artificial),	857	4472

It has been shown then,

1st. That the color of indigo is really a greenish blue when it is used as a pigment or in solution.

2d. The color of the dry cake is not only very black, but variable according to the mode in which it is handled.

Taking all this into consideration, it would appear desirable to allow the term indigo to fall into disuse, and to substitute for it ultramarine, the color of the artificial variety being intended.

ART. XIX.—*Notice of recent Additions to the Marine Fauna of the Eastern Coast of North America, No.* 8; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLV.

CEPHALOPODA.

Octopus obesus, sp. nov.

Male, remarkable for the great size of the spoon-shaped organ of the right arm of the third pair. Body relatively large, stout, oblong-oval, somewhat flattened above, obtusely rounded at the posterior end; soft and somewhat gelatinous in texture; skin, so far as preserved, smooth, soft. No cirrus exists above the eye, in our specimen, but the skin is not well preserved in that region. Eyes very large. Arms moderately long, the dorsal longest, others successively shorter; all somewhat laterally compressed at base, tapering to long, slender tips; a moderately developed web connects them together at base. The hectocotylized arm (third of right side), bears at the end a very large, broad and thick, but not very deep, spoon-like organ; its inner surface is crossed by eleven oblique, thick, rounded folds or ribs, ten of them converging backward to the median line and at their outer ends joining a marginal thickening; the distal end terminates in a median pointed lobe, with a thin, rounded, lateral lobe each side of it; the proximal border is formed by the last (eleventh) fold, which is V-shaped, with the apex pointing distally. A broad thin marginal membrane extends along the lower side of the arm, from the terminal organ to the base. The suckers have been partly detached from this arm. Suckers of all the arms moderately large, nearly globular

in form, rather numerous; the first six to ten from the base are nearly in one line, except on the left arm of second pair, and appear to form only a single row; in this part the inner face of the arm is narrow, and most so on the right arm of the second pair, and least on the left of the same pair; farther out this face becomes broader and the suckers are in two distinct rows; they are destroyed on the distal portion of all the arms. Color of body and arms mostly destroyed, but so far as preserved, pale pinkish, more or less thickly speckled with distinct reddish brown spots, most conspicuous at the bases of the arms and above the eyes (elsewhere the color is probably not so well preserved). Length of body, from posterior end to base of arms, 82^{mm}; to center of eye, 72^{mm}; to edge of mantle, beneath, 49^{mm}; to tip of right dorsal arm, 213^{mm}: left, 198; to tips of second pair, 200; to tip of right arm of third pair, 173; of left, 197; to tip of right of fourth pair, 187; of left, 178; to edge of web, 110; breadth of body, in middle, 46; breadth of head, across eyes, 38; breadth of dorsal arms, at base, 8^{mm}; diameter of largest suckers, 3^{mm}; length of spoon-shaped end of right arm of third pair (hectocotylized), 35; breadth, 16; length of rest of arm, to mouth, 65^{mm}.

Taken from the stomach of a halibut, 36 miles east from the N. E. Light of Sable Island, in 160 to 300 fathoms, by Charles Ruckley, of the schooner "H. A. Duncan," and presented by him to the U. S. Fish Commission, 1879.

This species differs from *Octopus Bairdii* V.,* and *O. piscatorum* V., from the same region, in its longer and larger body, and especially in having the basal suckers in a single row. The 'spoon' of the hectocotylized arm is much larger than in *O. Grönlandicus*, and larger and flatter than in *O. Bairdii.*

Octopus lentus, sp. nov.

Female, body broad, stout, depressed, slightly emarginate at the posterior end, soft to the touch and somewhat gelatinous in appearance; a thin, soft, free, marginal membrane runs along the sides and around the posterior end of the body, becoming widest (about 12^{mm}) posteriorly. Head large, broad, depressed, with the eyes large and far apart: above each eye there is a small, simple, conical, acute cirrus. A well-developed, thin web connects the arms, considerably above their bases, and then

* Although only males of this species were originally described, we have since taken large numbers of both males and females. The sexes differ but slightly, except in the hectocotylized arm of the male. The sexes apparently do not differ to any great extent in size. A second female specimen of *O. piscatorum* V. has also been received. It was taken by Capt. David Campbell and crew, of the sch. "Admiral," on the Grand Bank, N. lat. 44° 07′; W. long. 52° 40′, in 200 fathoms, December, 1879. It is nearest allied to *O. Grönlandicus*, (of which the males, alone, are known to me) and may prove to be only the female of the latter.

ans up to the tips as a broad margin to each arm. The arms re rather large, stout at base, with broad inner face, gradually apering to very slender tips; the first and third pairs are early equal in length; those of the second are also about qual in length to the fourth pair, but are somewhat shorter ian the first and third. The arms on the right side are all omewhat longer than the corresponding ones on the left. The rms, measuring from the beak, are more than twice as long s the body. The suckers are arranged in two distinct rows, the base. Color of head and body, above, and of body, beeath, deep reddish-brown, closely specked with darker brown, nd with many small roundish spots of whitish on the body nd arms.

Length, beak to end of body, not including marginal web, 0^{mm}; breadth of web, 22^{mm}; length of longest arms of right ide, $1{\cdot}12^{mm}$; total length, 194^{mm}; breadth of body, 40^{mm}; breadth f head, across eyes, 32^{mm}; of eye-openings, 10^{mm}; of eye-balls, 7^{mm}; length of mantle, beneath, 38^{mm}; length of first pair of rms, 112 and 105^{mm}; of second pair, 103 and 96^{mm}; of third air, 112 and 106^{mm}; of fourth pair, 94 and 97^{mm}; breadth of hose of the three upper pairs, 8^{mm}; of the ventral pair, 7^{mm}. 'aken off Nova Scotia, near Le Have Bank, in 120 fathoms, y Captain Samuel Peeples and crew of the schooner "M. H. 'erkins," and presented to the U. S. Fish Commission.

In the soft consistency of the flesh and skin this species esembles the preceding. The shorter and posteriorly emarinate body, and especially the great difference in the arrangeient of the suckers, render it very improbable that it is the emale of that species.

ECHINODERMATA.

Brisinga Americana, sp. nov.

A large and very showy species with fifteen to twenty long nd very spinose rays, which are high and much compressed iterally near the base, but farther out become depressed and aper gradually to the slender ends. In our specimen the disk s gone. Fifteen detached arms remain; some of them entire, ut mostly broken, probably by the spontaneous contractions f the creature when taken. According to the statement of he captors it had twenty rays, originally. The longest rays, s preserved in strong alcohol, are 353^{mm} (14 inches) long; reatest height (about 1·5 inches from base) 32^{mm} (1·26 inches), ot including spines; transverse diameter at same place, 16 to 9^{mm} (·65 to ·75 inch); transverse diameter at about the middle, xclusive of spines, 10 to 12^{mm}; height, 7^{mm}. The adambulaal plates bear a simple row of slender, acute spines, one to

each plate; they are comparatively short near the base of the arms, but soon become much longer and more slender, and so continue to near the end. Just outside of these, on each side, along most of the arm, there are transverse clusters of four or five very long, slender, acute, divergent spines, borne upon transverse prominent lateral plates, one of which occurs opposite about every fourth adambulacral plate; toward the base of the arms these clusters become gradually reduced, both in number and length of the spines, till two small ones remain, and finally only one; and still nearer the base, for about an inch, this disappears also, leaving the broad side, close to the swollen base naked of spines, except dorsally; the elevated basal region, except close to base, is crossed by series of transverse lateral and dorsal plates, in line with those described, and forming prominent ridges, which bear long, slender, sharp spines, in simple, transverse series; between these ribs the skin is naked and there are numerous slender scattered papulæ. The transverse rows of dorsal spines continue to or beyond the elevated region of the ray (nearly one-third of the length); beyond this the dorsal surface is covered with low, granular verrucæ, to the end. All the spines are enclosed, when perfect, by a loose, bag-like membrane, extending beyond their tips, and covered with minute pedicellariæ, granule-like in size and appearance, like those of the dorsal verrucæ. The ambulacral suckers are large and form two regular rows. Eyes, in alcohol, yellowish, well-developed. Length of adambulacral spines, at base of arm, 5^{mm}; in middle of arm, 8^{mm}; length of longest lateral spines, along middle of arm, 12 to 14^{mm}; including the sac, 16^{mm}. Color, pale orange-red, in alcohol, when first received, soon fading to whitish; when living probably bright red.

Taken off Nova Scotia, on the western part of Banquereau, in 175 fathoms, by Captain Samuel Peeples and crew, of the schooner "Addison Center," and presented to the U. S. Fish Commission.

This species is related to *B. coronata* G. O. Sars, but it has much larger and stouter arms, and much larger adambulacral spines, and more numerous lateral and dorsal ones. Our specimen was found clinging to the branches of *Paragorgia arborea*.

ART. XX.—*The Electric Light;* by F. E. NIPHER.

IN the Philosophical Magazine for January, 1879, p. 30, Mr. W. H. Preece gives a discussion, in which he shows the condition to be supplied in electric lighting, in order to obtain a maximum effect. In eq. 2, p. 31, he gives for the heat distributed to the incandescent material,

$$H=\frac{E^2 l}{(\rho+r+l)^2}$$

where ρ represents the battery resistance, and r and l represent the resistances of the connecting wires and an incandescent lamp, respectively.

For n lamps joined up in series, we must substitute nl for l, while if joined in multiple arc, we must put $\frac{l}{n}$ for l. In either case, the value of H is found to be a maximum, when the resistance of the lamp system is equal to that of the rest of the circuit.

Mr. Preece then proceeds on the assumption that this condition cannot be complied with, if n is large, reaching the conclusion that the amount of heat liberated in each lamp, varies inversely as the square of the number of lamps. This is true in either of the two cases discussed by him.

If, however, we have n lamps, arranged in n' parallel circuits, in each of which we have n'' lamps, the previous equation becomes

$$H'''=\frac{E^2\frac{n''}{n'}l}{(\rho+r+\frac{n''}{n'}l)^2}$$

With this arrangement it is *always* possible to supply the condition which makes H''' a maximum, entirely irrespective of the value of n. If

$$\rho+r=\frac{n''}{n'}l$$

we shall have

$$H'''=\frac{E^2}{4(\rho+r)}$$

or the total heat in n lamps is independent of the number of lamps.

The heat generated in each lamp will then vary inversely as the number of lamps.

St. Louis, Dec. 30, 1879.

SCIENTIFIC INTELLIGENCE.

I. Physics and Chemistry.

1. *Why the air at the Equator is not hotter in January than in July;* by James Croll.—The following, I think, is the explanation of the difficulty why the January temperature at the equator when the earth is in perihelion is not much higher than in July when in aphelion. The difficulty is more apparent than real, for if we examine the *indirect* results which follow from the present distribution of land and water, we shall see that there is no reason whatever why the air at the equator should be hotter in January than in July.

It is well known that, notwithstanding the nearness of the sun in January, the influence of the present distribution of land and water is sufficient to make the mean temperature of the whole earth, or, what is the same, the mean temperature of the air over the surface of the earth higher in July than in January. The reason of this is obvious. Nearly all the land is in the northern hemisphere, while the southern hemisphere is for the most part water. The surface of the northern or land-hemisphere, for reasons to which I need not here refer, becomes heated in summer and cooled in winter to a far greater extent than the surface of the southern or water hemisphere. Consequently when we add the July or midsummer temperature of the northern to the July temperature of the southern hemisphere, we must get a higher number than when we add the January or midwinter temperature of the former to the January temperature of the latter. For example, the mean July temperature of the northern hemisphere, according to Dove ("Distribution of Heat on the Surface of the Globe") is 70°·9, and that of the southern hemisphere 53°·6; add the two together and we have 124°·5, which gives a mean for both hemispheres of 62°·3. The mean January temperature of the northern hemisphere is 48°·9, which, added to 59°·5, the mean January temperature of the southern hemisphere, gives only 108°·4, or a mean of 54°·2. Consequently the air over the surface of the globe is hotter in July by 8° than in January, notwithstanding the effects of eccentricity. It is obvious that, were it not for the counteracting effects of eccentricity, the difference would be much greater. Ten thousand years ago, when eccentricity and the distribution of land and water combined to produce the same effect, the difference must have been far greater than 8°.

But it will be asked, How can this affect the air over the equator, which is not situated more on the one hemisphere than on the other? It is true that those causes have but little *direct* effect on the air at the equator, but *indirectly* they have a very powerful influence. The air is continually flowing in to the equatorial regions from both hemispheres. In fact, the air which we find

there is derived entirely from the temperate regions. In July we have the northern trades coming from a hemisphere with a mean temperature as high as 70°·9, and the southern trades coming from a hemisphere with a mean temperature not under 53°, while in January the former trades flow from a hemisphere as low as 50°, and the latter from a hemisphere no higher than 60°. Consequently the air which the equatorial regions received from the trades must have a higher temperature in July than in January. The northern is the dominant hemisphere; it pours in hot air in July and cold air in January, and this effect is not counterbalanced by the air of the opposite hemisphere. The mean temperature of the air passing into the equatorial regions ought therefore to be much higher in July than in January, and this it no doubt would be were it not, let it be observed, for the counteracting effects of eccentricity. The tendency of the present distribution of land and water, when our northern winter occurs in perihelion, is to counteract the effects of eccentricity. But ten thousand years ago, when our winters were in aphelion, that cause would coöperate to intensify the effects of eccentricity. In fact, it would actually more than double the effects then produced by eccentricity. Now if the influence of the present distribution of land and water is so great as not merely to counteract but to reverse the effects of eccentricity to the extent of making the mean temperature of the earth 8° warmer in July than in January, it is not surprising that it should be sufficient to make the equatorial regions at least as warm in the former as in the latter period.

The fact that the equator at present is not hotter when the earth is in perihelion, instead of being an objection to the theory that the glacial period was due to an increase of eccentricity, as some suppose, is in reality another strong argument in its favor, for it shows that a much less amount of eccentricity would suffice to induce a commencement of glacial conditions in the northern hemisphere than would otherwise be required, were it not for the circumstance referred to.

There is another cause which must also tend to lower the January and raise the July temperature of the equator, viz: the northern trades pass further south in January than in July, and consequently cool the equatorial regions more during the former than the latter season. The general tendency of the trades to lower the temperature of the equatorial regions more in January than in July is of course subject to modifications from the monsoons, the rainy seasons, and other local causes; nevertheless, so long as the present distribution of land and water endures, so long will eccentricity have a counteracting effect upon the temperature of the air at the equator, which but for that would be hotter in July than in January.

No knowledge whatever as to the intensity of the sun's heat can be obtained from observations on the temperature of the air at the equator. The comparatively cold air flowing in from the temperate regions has not time to be fully heated by the sun's

rays before it rises as an ascending current and returns to the temperate regions from whence it came. More than this these trades prevent us from being able to determine with accuracy the intensity of the sun's heat from the temperature of the ground; for the surface of the ground in equatorial regions is kept at a much lower temperature by the air blowing over it than is due to the intensity of the sun's heat. It thus becomes a very intricate problem to determine how much the surface of the ground is kept below the maximum temperature by the heat absorbed by the moving air.—*Nature*, Dec. 11, 1879.

2. *Temperature of the Sun.*—Professor F. ROSETTI, of the University of Padua, concludes a series of papers entitled—"Experimental researches on the temperature of the Sun," with the following remarks:—

The effective temperature of the sun may be defined as that temperature which an incandescent body of the same size placed at the same distance ought to have in order to produce the same thermal effect y if it had the maximum emissive power, i. e., $E=1$. In this place we could apply the formula

$$y = mT^2(T-\theta) - n(T-\theta);$$

and if we consider the surrounding temperature during the observations to have been about 24°, giving $\theta = 297$, we obtain

$$T = 10238^\circ{\cdot}4;$$

so that the effective temperature of the sun, represented in degrees Centigrade, is

$$t = 9965^\circ{\cdot}4,$$

if we only take into consideration the absorption produced by the terrestrial atmosphere. If we neglected this absorption we should have a lower temperature. In short, in the observations made, the maximum was obtained on September 28th at midday: this is represented by 210 scale-divisions, which gives y the value

$$y = 5{\cdot}6921 \times 210 = 1195{\cdot}3.$$

If we introduce this value into the formula, we obtain

$$T = 8883{\cdot}8,$$

giving

$$t = 8610{\cdot}8.$$

This result will be greatly modified if we take into account the absorption exercised by the solar atmosphere. According to Secchi, the solar atmosphere exercises a very powerful absorption on the rays which proceed from the photosphere: on account of this absorption only $\frac{12}{100}$ of the solar radiation pass beyond the atmosphere of the sun, while $\frac{88}{100}$ are absorbed by it. If we regard this value given by Secchi as correct, we can calculate the thermal effect which the sun would produce if it were without atmosphere. This effect would be

$$y = 1838{\cdot}5 \times \frac{100}{12} = 15320{\cdot}8.$$

ula gives

$$T = 20653 \cdot 7,$$

quently

$$t = 20380 \cdot 7.$$

: still two causes which can modify these results; but their effect is slight, since their influences are contrary mpensate one another. One of these causes is the value ecific emissive power of the sun, which may possibly be unity; and in that case the true temperature of the d be higher. The other cause is the transparency of ent strata of the solar atmosphere: although this is s nevertheless certain that we receive the rays from sev- posed strata; and although their temperature is certainly n that of the photosphere situated underneath, neverthe- ie radiation of the latter a portion of the radiation of ita joins itself; and consequently in that case a lower ire of the sun is sufficient to produce the heating meas- our instruments.

, then, that I may fairly conclude that the true tempera- e sun is not very different from its effective temperature, it is not much less than *ten thousand degrees* if we only the absorption of the terrestrial atmosphere, nor much n *twenty thousand degrees* if we also take into consider- absorption by the solar atmosphere, estimating the latter the total radiation of the sun.—*Phil. Mag.*, Supplementary).

Pseudophone.—For investigating the laws of Binaural * Professor S. P. THOMPSON has devised a little instru- ch he calls the *pseudophone*, and which, as he states, is gue of the pseudoscope of Wheatstone, since it illustrates of audition by means of the illusions it produces in the perception of space. It consists of a pair of ear-pieces with adjustable metallic flaps or reflectors of sound, n be fitted to the ears by straps and can be set at any ngle with respect to the axis of the ears, and can also be pon a revolving collar about that axis so as to reflect to the ears from any desired direction. In regard to its uthor says:

:imate we are able to make of the position of a source of dging solely by the relative intensities of the sensation in ears, depends upon our previous perceptions and upon ssion of a constant amount of effective auditory surface, istant angle subtended between the ears and the line of

pseudophone these angles are variable, and the amount ve surface can also be varied, and this without any :e, on the part of the person experimenting with the it, as to how much they may be varied. Hence the illusions which are now to be described.

* See this Journal, vol. xvii, 64, 322.

Suppose one flap to be adjusted at any angle of about forty degrees with the line of sight, in which position it is about most favorably situated to receive sounds from a point right in front of the observer; then if the other flap be adjusted to any angle greater or less than forty degrees, fewer rays of sound are reflected into the ear on that side than on the other, and the hearer imagines the source of sound to be situated on that side on which the sensation is more intense. Accordingly, to verify the perception, the hearer turns his head until both ears hear the sound equally loudly, and imagines then that he is looking in the direction of the sound, whereas he is looking at a point situated nearer to that side on which the larger effective surface exists. This observation agrees with Steinhauser's theory. The illusion is very easily obtained by means of a loud-ticking clock, but with some persons does not succeed unless their eyes are blindfolded; for when there is a conflict between the evidence of the eyes and the evidence of the ears, the tendency appears to be to believe the former rather than the latter.

A more striking illusion occurs when the flaps of the pseudophone are reversed and adjusted so as to reflect into the ears sounds which come from immediately behind the observer. In this case also, if a source of sound, situated anywhere behind the head, be observed, if the observer does not know how the flaps are adjusted, he will estimate it to be somewhere in front; and, on turning his head about until the sounds are equally intense, he judges himself to be looking straight at the source of sound, whereas it is in reality exactly in an opposite direction. This illusion succeeds well with a loud-ticking clock, well also with the human voice, but not well with a tuning-fork of medium pitch. In a room the experiment may succeed with a tuning-fork; but there is never the same clear and decisive impression as to the position of the sounding body. In the open air the writer has never succeeded in producing the illusion with a tuning-fork; for the sensation is one of a character from which it appears to be impossible to draw any precise judgment. The sound does not appear to *have* any precise locality. * * *

The illusion succeeds in the open as well as in-doors with the sound of a loud-ticking clock, and with the human voice; but with shrill sounds it succeeds best, notably with the sharp click of a metronome, and even with a metronome-bell.

Another experiment with the pseudophone, which gives rise to acoustical illusions, consists in setting one flap to catch sounds from the front, while the other catches sounds from behind or above the observer. Under these circumstances the sounds seem, as the observer moves his head, to come sometimes from the right, sometimes from the left, or sometimes from the ground.

Lastly, most of these experiments with the pseudophone can be repeated simply by holding the hands in front of the ears as flaps; but here the illusion does not always succeed, as the observer is conscious that his hands are reflecting to the ear sounds from a

certain direction, and so the judgment is sophisticated.—*Phil. Mag.*, November, 1879.

4. *Explosion of Carbonic Acid in a coal mine.*—M. DELESSE has given in the Comptes Rendus a short statement in regard to an explosion in the coal mine of Rochebelle (Gard), which caused the death of three miners. This explosion is explained as having been produced, not by fire-damp, for the detonation was not accompanied by flame nor was there any trace of burning found afterward, but by carbonic acid. It is suggested that the production of the gas was probably due to the action of a neighboring deposit of iron pyrites. This pyrite is strongly oxidized and in a complete state of decomposition; this would give a continual source of sulphuric acid, which, dissolving little by little in the subterranean waters, would meet the limestone below. In consequence a large amount of carbonic acid would be disengaged, penetrating the fissured beds of coal and finally, as the author argues, accumulating under so great a pressure as to lead to an explosion.

5. *On the Heat of Formation of Cyanogen.*—Since cyanogen is the only electro-negative compound radical thus far isolated, BERTHELOT has thought it desirable to determine the heat of its formation. For this purpose he burned it by means of oxygen, and found for the heat of its combustion $CN = 26$ grams $= +132{\cdot}3$ calories. Now the heat of combustion of the 12 grams of carbon it contains, referred to the condition of the diamond, is 94 calories. The difference is 38·3 calories, which is precisely the heat absorbed in the formation of cyanogen from its elements, C (diamond) $+$N $=$CN (gas) absorbs $-38{\cdot}3$ calories. This fact, that cyanogen is formed from its elements with absorption of heat, was announced in 1864, and is now confirmed. Like acetylene C_2H_2 and nitrogen dioxide N_2O_2, cyanogen absorbs heat in its synthesis. This, Berthelot thinks, may be the reason why this body manifests in combining an energy comparable to that of the elements.—*Bull. Soc. Ch.*, II, xxxii, 385, Nov., 1879. G. F. B.

6. *First Book in Qualitative Chemistry*, by ALFRED B. PRESCOTT. 160 pp. 8vo. New York, 1879. (D. Van Nostrand).—This little work has a character of its own in that it is designed not only to teach the ordinary simple method of analysis, but also to give the student at the same time a wider knowledge of chemical relations, and chemical facts, than he is likely to gain if his attention is directed exclusively to the differences upon which analytical methods are based. In the hands of a good teacher this book should give excellent results.

7. *Notes on Assaying and Assay Schemes;* by P. DE PEYSTER RICKETTS, E.M., Ph.D. Second edition, revised and enlarged. 210 pp. 8vo. New York, 1879. (J. Wiley & Son.)—We noticed this useful volume on its first appearance. The second edition contains important additions and corrections. Dr. Chandler's happy conception of the Assay Ton (A. T.), by which the ton of 2000 lbs. stands to the A. T. as one ounce Troy to one milligram, is now in general use in the United States, and is of course

used in these "Notes." Dr. Ricketts is at the head of the assay laboratory of the Columbia College School of Mines, and these "Notes" are the daily guide of the students of that institution. It is a particularly practical book and well adapted to its objects.

8. *Chemical Problems*, by JAMES C. FOYE. 43 pp. 8vo. Appleton's Misc., 1879.—Many teachers may find their work facilitated by having a series of problems on the fundamental principles of chemistry prepared for them.

II. GEOLOGY AND MINERALOGY.

1. *A Manual of the Geology of India.* Chiefly compiled from the Observations of the Geological Survey by H. B. MEDLICOTT, M.A., Superintendent Geological Survey of India, and W. T. BLANFORD, F.R.S., Deputy Superintendent. 2 vols. roy. 8vo, in all 820 pp., with a map, and 21 lithogr. plates.—The authors of this Manual of India Geology are prominent members of the corps connected with the Government Geological Survey; and the work may therefore be received as a faithful presentation of the latest results obtained. The facts and views are ably set forth, and those relating to fossils are well illustrated in the many plates. The work has a high interest to geologists of the other hemisphere, because of the striking contrasts with the geology of Europe and North America which it affords, while sustaining the same general truths and principles.

The work is divided into Part I (occupying volume i), treating of the Peninsular area of India, and Part II (volume ii), of the Extra-peninsular area; and both the physical geography and geology of these areas are treated of.

The following are some of the peculiarities in the geology of India which are described at length in the volumes.

(1.) The division into Peninsular and Extra-peninsular India by the broad plain of the Indus and Ganges, at the foot of the interior mountain region; "the Extra-peninsular area is geologically an intrinsic portion of the Asiatic continent, whilst Peninsular India is not."

(2.) The absence of *marine* fossiliferous beds older than Tertiary in Peninsular India, excepting some Jurassic and Cretaceous in the Cutch and Jessalmir just northwest, and similar beds along the east coast, although there are unaltered sedimentary rocks of great thickness from the Cretaceous to the Lower Silurian (?), with metamorphic rocks underneath; first, a great "Vindhyan" formation, north of the Narbada, 12,000 feet thick, consisting of limestones and shales in many alternations; and, secondly, the Gondwana, or plant-bearing and coal-bearing series, of wide extent, the lower portion of which (the Talchir and Damuda groups), are referred to the Permian and Triassic, and the upper (the Mahadeva and Rajmahal) to the Jurassic.*

* The only animal fossils of the Damuda series are an Estheria, some Labyrinthodont and true Reptiles (a Dicynodon (also a Karoo form), and the Dinosaur, *Ancestrodon Indicus*).

The occurrence of marine fossiliferous beds of Silurian, Devonian, Carboniferous, Triassic, Jurassic, Cretaceous and Tertiary age in the mountain regions of the Extra-peninsular area.

(3.) The Coal-period of the country having its commencement in the Permian and reaching its maximum in the Triassic (the period of the Damuda group): showing that the era of gentle oscillations about such a mean plane of level as would make wide-spread marshes in alternation with wide-spread shallow waters, came later than in the hemisphere of Europe and America, and that these diverse hemispheres did not correspond in limit with the north and south hemispheres of the sphere.

(4.) A close relation in species between the Coal-plants (species of *Glossopteris*, etc.), of the Talchir and Damuda groups and those of the Coal-fields of Eastern Australia, and also those of Southern Africa (the Karoo beds), showing that these three distant portions of the globe had certain common relations in that era.

(5.) A close relation between the Reptilian and Amphibian fauna of the Later Gondwana beds and that of the upper beds of the Karoo series.*

(6.) The existence, in the Talchir group, among finer strata, especially toward the base of the group, of beds of bowlders, the bowlders rounded, from half an inch in diameter to fifteen feet and thirty tons in weight, some of them with scratched and smoothed surfaces; and of similar bowlder beds in the lower of the South Africa deposits in the Karoo region.

(7.) The existence in the Lower Vindhyan series, in Southern India, of a diamond-bearing conglomerate or grit, ten to twenty feet thick (of dark gray, red and brown colors), which is explored for diamonds by means of shallow pits and short galleries—the diamonds supposed to be probably "of detrital origin," like the pebbles and other material of the enclosing rock; also of another similar diamond-bearing conglomerate in the Upper Vindhyans, on the borders of the Bundelkand gneiss; besides alluvial diggings.

(8.) In Extra-peninsular India, the occurrence of Eocene Nummulitic strata, with underlying Cretaceous and usually overlying beds of later Tertiary, at a height of 7,000 feet, on the tops of the hills of Khirthar, in Western Sind, and still higher, in the Pun-

The upper part of the Gondwana, in the Rajmahal hills and elsewhere, contains numerous species of Cycads as well as Ferns and Conifers, which indicate a Jurassic age, and a relation also to the flora of beds overlying the Karoo series of South Africa. A number of fossil fishes, and some Reptile remains occur in the beds, and near Ellore and Ongole, and near Madras, in the upper beds, there are Ammonites and other Mollusks, having Jurassic affinities. In Cutch and to the northwest are other Jurassic rocks, about 6,000 feet thick, containing numerous marine fossils, and it is the only case of the kind in the Peninsula of India. The fossils are species of *Trigonia*, *Gervillia*, *Pholadomya*. *Lima*, *Exogyra*, *Belemnites*, various *Ammonites*, etc. *Trigonia ventricosa* occurs also in the uppermost Jurassic rocks of South Africa, as well as in the upper beds of the Gondwana series, near Rájámahendri. Marine Cretaceous beds with fossils occur in Cutch, in Pondicherry and Trichonopoly in Southern India, and between Mandlesir and Broach in the Narbada valley. The marine Tertiary beds of the Peninsular area are confined to a narrow fringe along or near the coast.

jab, to the north, along the Suleman Range to Peshawar; in the "Salt Range;" in Northern Punjab, through the Hazára and the Murree Hills, and other hills west of the Indus; and along a region 200 miles or more long and 25 wide in Tibet, in the upper Indus valley, 15,000 feet above the sea level.* (The statement, by Dr. Thomson, as to the occurrence of Nummulitic beds on the Singhi Pass, at a height of 16,600 feet, is said to need confirmation, because of the importance of the fact, if true.)

(9.) A thickness of Tertiary in the Sub-Himalayas (a range of mountain ridges, fifty miles in width, 5,000 to 8,000 and rarely 12,000 feet high) of 12,000 to 15,000 feet, with the beds much folded, but conformably with the underlying beds; in the Punjab, of 25,000 feet thick, 15,000 feet being of the Siwalik formation or Upper Tertiary; in Sind, in the Mountains of Khirthar, 8,000 to 10,000 feet for the Pliocene (Manchhar group) alone, the beds much folded, (related to the Pliocene of the Siwalik Hills).

(10.) In the Punjab, beyond the parallel of 32°, between the Indus and Jhelun, the "Salt Range," including strata ranging from the Silurian (?) to the Pliocene, many containing marine fossils, the Sub-Carboniferous limestone being well displayed and extending into Kashmir.

(11.) Salt-bearing beds (Silurian?) at the base of the series of the "Salt Range," the salt layers often 100 feet thick, and at the Mayo Mines of Khewa, containing 550 feet of pure and impure salt, in a thickness of 1,000 feet; also, in the Kohát region, in the Punjab, underneath Nummulitic beds, beds of rock salt and gypsum of great thickness, exceeding 1,000 feet near Bahádur Khel, with a width of outcrop of a quarter of a mile, and ridges of rock salt 200 feet high standing in the region.

(12.) Trap rocks, doleryte and basalt—the "Deccan trap"—of great geographical extent, reaching, with even horizontality, from the sea-coast at Bombay (72° 51′ E.) to the head of the Narbada (82° E.), and from near Belgaum (15° 35′ N.) to north of Goona (25° N.), an area, covering about 16 degrees of longitude and 9½ of latitude, little less than 200,000 square miles (the railway from Bombay to Nágpur, 519 miles long, never leaving the volcanic rocks until it is close to the Nágpur station); and all subaerial in origin; probably erupted at or near the close of the Cretaceous or during the Lower Tertiary, in successive outflows occurring at intervals during a long period; the thickness near Bombay, 6,000 feet; in Cutch, about 2,500; in Sind, only 200 in two bands; in Belgaum, at the southern limit, 2,000 to 2,500 feet; to the south-east, near Rájámahendri, 100 to 200 feet.

* The Indus in the Central Himalayas flows in a direction about N. 50° W., between the Zanskar gneiss range on the south and that of Ladak on the north; and these Eocene beds extend, according to Stoliczka, from Kargil, on the west, eastward for more than 200 miles, to beyond the eastern limit of his explorations. The Zanskar contains also 8,000 to 9,000 feet of fossiliferous Cretaceous, Jurassic, Triassic, Carboniferous and Silurian beds, all conformable. The Zanskar range contains several peaks 20,000 feet in height, and "has a right to be considered the principal continuation of the Himalayan chain." Its gneiss is "to some extent, at least, a rock formed of converted Paleozoic strata."

(13.) Other extensive trappean outflows in the Rajmahal region, west of the delta of the Ganges, 2,000 feet thick, probably from Jurassic to Upper Cretaceous in age, but supposed by some to have been cotemporaneous with the Deccan outflows, with "little petrological distinction between the traps" of the two regions; and still others in the Sylhet region, east of the delta, overlaid by Cretaceous rocks.

(14.) A line of eruptive rocks on the Upper Indus, from Kargil eastward, accompanying the Eocene strata "from end to end."

The above indicate some of the points which the reader will find presented in full in the volumes.

With regard to the movements producing the Himalayas, the work makes the following remarks in the brief geological summary with which the work commences (pages lvi, lvii).

We cite, in closing this notice, the following general remarks (from pages lvi, lvii) on the *Origin of the Himalayas.*—During the interval that has elapsed since Eocene times, whilst no important movements, except small and partial changes of elevation, can be traced in the Peninsula, the whole of the gigantic forces, to which the contortion and folding of the Himalayas and other Extra-peninsular mountains are due, must have been exercised. The Sub-Himalayan Eocene beds were deposited upon uncontorted Paleozoic rocks; and although the Himalayan area was probably in great part land at a much earlier period, there is no reason for believing that this land was of unusual elevation, whilst the direction of the Himalayan ranges is clearly due to post-Eocene disturbance. It will be shewn, in the chapters relating to the Sub-Himalayan rocks, that the movement has been distributed over the Tertiary and post-Tertiary period; and a great portion is of post-Pliocene date. Indeed, the fact that earthquakes are now of common occurrence in the Himalayas, the Assam hills, Burma, Cutch, and Sind, and that many of the shocks are severe and some violent, whilst the Peninsular area is but rarely affected by earthquakes, may indicate that the forces, to which the elevation and contortion of the Himalayas are due, are still in action; and that the highest mountains in this world owe their height to the fact that the process of elevation is still in progress, to a sufficient extent to counterbalance the effects of denudation.

In Sind and the Sulemán ranges, there is much probability that some movement took place during Miocene and Pliocene times. Some slight unconformity between beds, elsewhere conformable, and the absence of different groups in parts of the country, may thus be explained; but the principal disturbance is clearly of post-Pliocene date. To the eastward, in Burma, however, the Pliocene formations of the Irawadi valley are but little disturbed, and the Miocene beds, although contorted, are unaltered; whilst many of the Eocene and Cretaceous rocks are greatly changed, besides having undergone excessive disturbance and folding. These facts may, perhaps, indicate that the disturb-

ing forces were more severe to the eastward in middle Tertiary times, and that the main action to the westward was of later date: a view partly supported by the fact that there is evidence of elevation having taken place in the Himalayas near the Ganges and Sutlej, at an earlier period than farther to the westward. In the Simla area, there is marked unconformity, due evidently to upheaval and denudation combined, between the Sirmûr and Siwalik series, and between the lower, or Nâhan, group of the Siwalik series itself and the next overlying sub-division; whereas farther west, in the Northern Punjab, all the groups follow each other in apparently conformable sequence. The evidence, however, is not sufficient to prove that the contortion to the eastward is older than to the westward; and the absence of any important break in Burma is opposed to the suggestion of great movements having taken place in that country in early or middle Tertiary times.

It is evident that the forces, to which the principal ranges in the Extra-peninsular area owe their direction, have not only been exerted throughout a considerable portion of the Tertiary period, but that these forces have acted contemporaneously, at all events in the post-Pliocene period."

2. *Note on the Trilobite, Atops trilineatus of Emmons;* by S. W. Ford.—In his paper on "*Fossils of the Utica Slate and Metamorphoses of Triarthrus Beckii*," noticed on page 152 of this Journal for August, 1879, Mr. C. D. Walcott includes in his list of synonyms of *Triarthrus Beckii*, *Atops trilineatus* Emmons, 1844, Taconic System, p. 20; and *Atops trilineatus* Emm., 1846, Agr. Rep. N. Y., vol. i, p. 64. The figures are the same in the two publications cited. The species represented by Emmons is not the *Triarthrus Beckii*, and of the Utica Slate, nor is it that species and of the Hudson River group, as maintained by Hall, but has since been shown to belong to the genus *Conocoryphe* and to characterize the Primordial. It has not yet been met with beyond the State of New York, nor at any point west of the Hudson River. In an earlier part of his paper, Mr. Walcott treats of the views entertained by Mather concerning the rocks upon the east side of the Hudson, quoting from that geologist to prove that he considered them to represent all the members of the Champlain division, and these only; and he then proceeds to speak of "Mr. Dale's discovery of an old locality given by Mather," and the writer's "verification of the presence of a lower member of the Champlain division by paleontological evidence," as serving simply to confirm Mather's views.

Whatever may be thought of Mr. Dale's discoveries, I am satisfied that their intrinsic value will not be at all lessened by Mr. Walcott's method of putting things. The important fact still remains, that, up to the date of Mr. Dale's discovery of Hudson River fossils at Poughkeepsie, the age of the slates occurring there was unknown. With regard to myself I may say that I am far from regarding the Primordial beds of Troy, N. Y., as representing any portion of the Champlain division as generally under-

stood, and have so expressed myself in former papers. The evidence respecting the horizon of these beds is mainly paleontological; and this, as it at present stands, shows that their fauna, though closely linked generically with that of the Potsdam sandstone (or true base of the Champlain division) on the one hand, and the Acadian on the other, yet has a decided *leaning* in this respect toward that of the Acadian. Specifically it is entirely distinct from both. Until, therefore, more is known upon the subject, it seems to me an obvious over-reaching of facts to refer the beds in question unqualifiedly to the Champlain division of the New York System.

New York, December 12th, 1879.

3. *List of Papers on the Taconic System;* by JAMES D. DANA.—As an Appendix to my last paper on the Taconic System, published in vol. xvii of this Journal (May, 1879, p. 375), I have prepared a list of the principal papers on the subject. It contains those treating of the true original Taconic, and of the changes in the limits of the Taconic system which Emmons introduced; but the papers which bear only on the age of accessories to the system are not included, since they never had any right to a place in the system and their age has no bearing on the question as to the age of the true Taconic. The list is in two parts; first, that of papers sustaining the pre-Silurian (pre-Potsdam) age of the Taconic system; and secondly, that of papers adverse to this view of their age.

I. IN FAVOR OF ITS INFERIOR POSITION AND UNCOMFORMABILITY TO THE NEW YORK SILURIAN.

EBENEZER EMMONS: Rep. Geol. New York, 4to, 1842, pp. 113–164; announces the Taconic system as Lower Cambrian, and includes in it, besides the schists o the Taconic Mountains (in the vicinity of which, at Williamstown, Professor Emmons for a while lived) and other slates to the north, and west to the Hudson, also the associated crystalline and semicrystalline limestones and quartzyte.—IDEM: Rep. Agric., New York, Part v, 4to, 1846, pp. 45–112; describes the system with more detail, and extends it to include rocks in Maine, Rhode Island and Michigan.—IDEM: American Geologist, 8vo, volume i, 1855, Part ii, pp. 1–124; extends the system from Maine to Georgia, divides it into Upper and Lower, the slates, limestones, and magnesian slates of the original Taconic, with their supposed equivalents, being made the Lower, and some added fossiliferous rocks [Primordial and later], with their supposed equivalents, the Upper.—IDEM: Report on the North Carolina Geol. Survey, 8vo, 1856, pp. 49–72.

E. & C. H. HITCHCOCK: Report on the Geology of Vermont, 2 vols., 4to, 1861; sustains the system, but half strangles it by the paleontological facts it reports.—P. MARCOU, Comptes Rendus, Nov. 4, 1861, and Proc. Boston Soc. Nat. Hist., 1862; adds the Potsdam sandstone and the gneiss of the Green Mountains to the Taconic system.

T. S. HUNT: Proc. Boston Soc. Nat. Hist., xix, 275, 1878; refers the "Upper Taconic," "wholly uncrystalline," to "the Quebec Group of Logan;" but the "Lower Taconic," here called *Taconian* (and made to include the crystalline schist of the Taconic Mountains, "along the outcrop" of which occur "the great masses of brown hematite ore" [or limonite], associated with magnesian limestones, from Vermont to Alabama), to the lowest Cambrian, or a still lower formation. containing *Scolithus* and *Eozoon*.—IDEM: Pennsylvania Geol. Report, on Azoic Rocks, Part i, 1878; uses the name *Taconian* (p. 207), with the same definition, but makes the Upper Taconic to include the Quebec Group and (pp. 115, 116, 206) organic remains of the European Cambrian at least as low as the Menevian."

II. In favor of the identity of the Taconic system with part or all of the New York Lower Silurian. (The Lower Silurian is called *Champlain Division* by Mather).

H. D. & W. B. Rogers: Proc Amer. Phil. Soc., Jan. 1, 1841; make the slates of the Taconic Mountains and the rocks east and west to be Lower Silurian, and refer the slates to the Hudson River group.—W. W. Mather: Report Geol. N. York, 4to., 1843; gives many sections and announces the same conclusions, arguing against the Taconic system.—H. D. Rogers: Address, etc., Rep. Amer. Assoc. Geol. & Nat., for 1844, p. 67, and Amer. J. Sci., xlvii, 137, 1844; urges the same views essentially.—James Hall: ibid., p. 68.

T. S. Hunt, "of the Geological Commission of Canada:" On the Taconic System, Report Amer. Assoc., for 1850 (New Haven meeting) says, "The results of the [Canada] survey have shown, as I had the honor to state at the last annual meeting at Cambridge [in 1849], that the Green Mountain rocks are nothing else than the rocks of the Hudson River group with the Shawangunk conglomerates, in a metamorphic condition."—James Hall: N. Y. Palæontology, vol. iii, p. 15, 1859.—T. S. Hunt: Amer. J. Sci., II, xxxi, 402, 1861 (after Logan's defining of the Quebec group); says, "the Quebec group with its underlying shales is no other than the Taconic system of Emmons."—Idem: ibid., xxxii, 427, 1861; makes the Taconic, exclusive of the slates, equivalent of the Calciferous, adding that "it remains to be seen whether Dr. Emmons can retain from the wreck of his system, the lower slates as a Tacanic formation older than the Potsdam."—W. E. Logan: Geology of Canada, 8vo, 1863, p. 934; makes the system to consist, "for the greater part at least, of the strata of the Potsdam and Quebec Group."—J. D. Dana: Manual of Geology, 1863; cites and adopts the views just mentioned.—James Hall and W. E. Logan: Amer. J. Sci., II, xxxix, 96, 1865; refer the Hudson River slates south of Albany to the Quebec group.—T. S. Hunt: Address, etc., Rep. Amer. Assoc., for 1871; refers the Stockbridge or Green Mountain limestone to the Quebec group, and states that the conclusion of Rogers and Mather referring the Taconic system to the "Champlain Division" of the New York rocks had been sustained by subsequent observations (pp. 15 and 23).

J. D. Dana: On the Rocks of the vicinity of Great Barrington, Mass., Amer. J. Sci., III, iv, vi 1872, 1873; gives sections showing the *conformability* of the Taconic slates, "magnesia schists" (slates and schists making the Taconic Mountains), Stockbridge limestone, and quartzyte (the original Taconic rocks of Emmons), and makes the limestone (on the basis of Billings's report of Wing's discoveries). Trenton and Chazy, and the Taconic schists and slates of Hudson River age.—A. Wing: Discoveries in Vermont, ibid., xiii, 1877; shows, *by their fossils*, that the "Stockbridge limestone" and "Sparry limestone" of the Taconic System of Emmons in Vermont, are Lower Silurian, from Potsdam to Trenton, inclusive, and that the Taconic slates *overlie* the limestones.—J. D. Dana: On the Relations of the Geology of Vermont to that of Berkshire, ibid., xiv, 1877; gives new sections proving the conformablity before announced, and sustains the conclusion that the Taconic schists and slates (those of the Taconic Mountains) are of Hudson River ago, and the limestones Lower Silurian, and shows also that mica schist, gneiss and other crystalline rocks are included among the *conformable* Lower Silurian strata.—Frederick Prime, Jr.: Lower Silurian Fossils in limestone associated with Hydromica Slates in Eastern Pennsylvania, ibid., xv, 261, 1878; shows the Chazy or Trenton age of the rocks, which are part of the so-called Taconic, and are like those of Berkshire.—T. Nelson Dale: Discovery of fossils, *proving the Hudson River age* of the supposed Taconic Poughkeepsie slates.—J. D. Dana: On the Hudson River Age of the Taconic schists, ibid., xvii, 375, 1879; announces the discovery of Trenton fossils in the Barnegat or Wappinger Valley limestone (which adjoins the Poughkeepsie slates), and proves the conformability of the Poughkeepsie slates with the slates of the Taconic Mountains, as exhibited in Mather's sections and the continuity and conformability of the Dutchess County slates and limestones with those of the Taconic System of Massachusetts and Vermont.—W. B. Dwight: Fossils of the Wappinger Valley Limestone, ibid., 389; adds to the number of localities, and gives lists of Trenton fossils, 50.—Whitfield: On the occurrence of Maclurea of the Chazy beds in the Barnegat Limestone near Newburgh, New York, ibid., xviii, 227, 1879.—W. B. Dwight: On Calciferous as well as Trenton fossils in the Barnegat lime-

stone at Rochdale and in Trenton in the same near Newburgh, N. Y., ibid., xix, 71, 1880.—J. P. LESLEY: On the discovery by P. Frazer, of Hudson River or Trenton *Buthotrephis* in slates on the Susquehanna, near the borders of Pennsylvania and Maryland, ibid., xix, 71, 1880.—Proc. Amer. Phil. Soc., xviii, 365.

4. *The Cave Bear of California;* by E. D. COPE.—In exploring a cavern in the Carboniferous limestone of Shasta county, Cal., James D. Richardson discovered the skull of a bear beneath several inches of cave earth and stalagmite. The specimen is in a good state of preservation, and demonstrates that the cave bear of that region was a species distinct alike from the cave bear of the East (*Ursus pristinus*), and from any of the existing species. In dimensions the skull equals that of the grizzly bear, but it is very differently proportioned. The muzzle is much shorter, and is wide, and descends obliquely downward from the very convex frontal region. It wants the large postorbital processes of the grizzly, but has the tuberosities of the polar bear (*U. maritimus*), which it also resembles in the convexity of the front. Sagittal crest well developed. Three (one median and posterior) incisive foramina: three external infraorbital foramina. The teeth are large, and the series presents the peculiarity of being without diastema. The crowns of the premolars are not preserved, but if there were not three premolars, the second tooth has two well-developed roots. First true molar with but two external and one internal tubercle. The absence of diastema renders it necessary to separate this bear from the true *Ursi*, and I propose to regard it, provisionally, as a species of *Arctotherium* Gerv. The canine teeth are large and compressed at the base. Length of cranium along base from below apex of union to premaxillary border, 0·387^{m}; length to posterior nares, ·202; elevation of forehead vertically above the posterior extremity of the last molar, ·141; width between inner border of posterior molars, ·076. The species may be called *Arctotherium simum*.—*American Naturalist*, December, 1879.

5. *On the Miocene Fauna of Oregon;* by E. D. COPE.—This paper, published in the Proceedings of the American Philosophical Society, Dec. 5, 1879, is the third by Professor Cope on the Miocene Mammals of Oregon. The first appeared in the Proceedings of the same society for November, 1878, and the second in the Bulletin of the United States Geological Survey of the Territories for February, 1879. The latter article contains an enumeration of seven species of mammals, discovered in the Truckee beds of the White River formation of Oregon. Since the date of the latter paper Professor Cope has been engaged in exploring the region; "the expeditions being mostly under the direction of Jacob L. Wortman." This paper contains the descriptions of some of the new species obtained, namely: *Hesperomys nematodon*, *Sciurus Vortmani*, *Paciculus insolitus*, *Canis lemur*, *Amphicyon entoptychi*, *Archælurus debilis*, *Hoplophoneus platycopis*, *Chænohyus decedens*, *Thinohyus trichænus*, *Palæochœrus subæquans*, *Merycopater Guiotianus*, *Coloreodon ferox*, *Coloreodon macrocephalus*. Professor Cope states that Mr. Wortman, to whom he is indebted

for several of the above, has sent remains also of *Lacertilia* and *Ophidia*, orders previously unknown from the Miocene of Oregon, but made known by him as occurring in the White River formation of Colorado in 1873.

6. *Ueber die erzführenden Tieferuptionen von Zinnwald-Altenberg und über den Zinnbergbau in diesem Gebiete;* by EDWARD REYER. *Tektonik der Granitergüsse von Neudeck und Karlsbad und Geschichte des Zinnbergbaues im Erzgebirge;* by the same. *Banka und Bilitong;* by the same.—The earlier studies of Dr. Reyer, entitled, "die Euganeen: Bau und Geschichte eines Vulcanes," and "Beitrag zur Fysik der Eruptionen und der Eruptivgesteine," are already well known by those interested in the subjects of which they treat. The series of papers whose titles are given above are based in part upon the theories advanced in these former memoirs. They contain detailed descriptions of the method of occurrence of the tin ore in the Erzgebirge of Bohemia, speculations as to its genesis, and also many valuable and interesting facts in regard to the history of the tin-mining industry.

7. *Brachiopodes: Etudes Locales.* Extraits du Systême Silurien du centre de la Bohême; vol. v, Brachiopodes. I. Variations observées parmi Brachiopodes siluriens de la Bohême. II. Distribution verticale des genres et espèces de Brachiopodes dans le bassin silurien de la Bohême. III. Connexions spécifiques établies par les Brachiopodes entre les faunes siluriennes de la Bohême et les faunes paléozoïques des contrées étrangères; par JOACHIM BARRANDE. 356 pp. and 7 plates, 4to. Prague and Paris, 1879.

8. *Geological Survey of Japan.* Reports of Progress for 1878 and 1879; by BENJ. SMITH LYMAN. 266 pp. 8vo. Tookei, 1879.

9. *Lethæa Geognostica, oder Beschreibung und Abbildung der für die Gebirgs-Formationen bezeichnendsten Versteinerungen,* herausgegeben von einer Vereinigung von Paläontologen. I Theil, Lethæa palæozoica von FRED. ROEMER. 1ste Lieferung. 324 pp. 8vo. Stuttgart, 1880 (E. Schweizerbart'sche Verlagshandlung—E. Koch). An Atlas to this work was published in 1876; it contains sixty-two plates, illustrating the fossil plants and animals of the successive Paleozoic formations, from the Cambrian to the Permian inclusive.

10. *Neues Jahrbuch für Mineralogie, Geologie, Paleontologie.*—A new decade of the "Jahrbuch" begins with 1880, and with it it is announced several changes will be made which are calculated to increase its usefulness. There are to be in future six numbers yearly, in two volumes, which together will include one-half more matter than the annual volumes hitherto issued. Various other changes in the selection and arrangement of the matter (some of them of considerable importance), are also proposed. The editors, Professors Benecke, Klein and Rosenbusch are doing a great service to science in perfecting and making more complete the journal which has been intrusted to their care.

11. *Mineralogische Notizen von* A. VON LASAULX.—Professor Lasaulx describes a new mineral species under the name of *Tita-*

nomorphite. It occurs as an alteration product, forming a white coating about a nucleus consisting of rutile or menaccanite, or both. This coating has in part a radiated fibrous structure, but on the outside is granular. The grains in some instances admitted of a crystallographic and optical examination, which showed a close relation between the mineral and titanite. An analysis by Bettendorff afforded TiO_2 74·32, CaO 25·27, FeO tr=99·59, which corresponds to the formula $CaTi_2O_5$. Found in the amphibolyte of the "Hohe Eule," Silesia. It is regarded by Lasaulx as probably identical with the white decomposition product from menaccanite or rutile often observed in microscopic sections of rocks but hitherto of uncertain composition.

Professor Lasaulx also describes a manganese vesuvianite (3·23 p. c. MnO) from the neighborhood of Jordansmühl, in Silesia, and gismondite from the basalt of Schlauroth, near Görlitz. The crystals of gismondite are shown to be generally twins, belonging to the triclinic system.—*Zeitsch. Kryst.*, iv, 162.

12. *Mineralogische Notizen*, von V. VON ZEPHAROVICH.—Professor Zepharovich describes interesting crystals of calcite and cerussite from Bleiberg, the former with the rhombohedron $R\frac{4}{3}$; also of sulphur, pyrite, and arsenical pyrites.

13. *Ueber die optische Orientirung der Plagioklase* von MAX SCHUSTER.—The results reached by DesCloizeaux in his optical examination of the triclinic feldspars were regarded by him as strong arguments against the correctness of the theory of Tschermak, that they are isomorphous mixtures of anorthite and albite in varying proportions, with these two species as the extremes. The subject has been farther investigated by Schuster, and as his result, he states:—that the lime-soda feldspars form in their optical relations a series analogous to that which connects them in their other characters; and further, each definite ratio in the mixture of the albite and anorthite corresponds to a definite optical relation approaching the one or the other of these two species. It is also shown that microcline and orthoclase are related to the other feldspar species in the position of the plane of the optic axes, and in the position of the positive bisectrix.—*Ber. Ak. Wien*, lxxx, July, 1879.

14. *Ueber den Perowskit von* H. BAUMHAUER.—The true crystalline form of the rare species perofskite has long been in question, and has been discussed by DesCloizeaux, Kokscharow, Hessenberg and others. Baumhauer has applied the method of etching to crystals from several localities, and has confirmed an opinion previously expressed by others, that they belong in fact to the orthorhombic system.

III. BOTANY AND ZOOLOGY.

1. *The Botanical Gazette, a Paper of Botanical Notes*, edited by Prof. J. M. Coulter and M. S. Coulter, has completed its fourth year, and its existence is now assured. The principal editor is now a professor in Wabash University, at Crawfordsville, Indi-

ana, where the Gazette is now published, in monthly numbers, at the low price of a dollar per year. It is an organ for communication among botanists, for the prompt publication of notes and observations, and of those contributions to knowledge which every accurate observer may do his part in, but which must be collected in order to be preserved and utilized. New species are published or announced in it, but it is rather an organ for new observations and botanical news. It is well conducted; it is very useful; we learn that it is in a condition which ensures its continuance, and that every increase in the subscription will go toward increasing its value. Our botanists should now see that it is worthily supported. Indeed they can hardly do without it. A. G.

2. *Additions to the Botanical Necrology of* 1879.—Our obituary list was drawn up earlier than usual, so that it might appear in the January number of the Journal. Two additions are already to be made to it.

FERDINAND LINDHEIMER died, at New Braunfels, Texas, in the early part of December, at the age of about 78. The Texan newspaper which announces his decease states that he was a volunteer in the Texas revolution under Gen. Houston. He was for many years editor of a German newspaper published at New Braunfels. He was an assiduous and excellent collector and a keen observer; the notes upon his specimens are full and discriminating, and added not a little to the value of the collections which were distributed by his friend and correspondent, Dr. Engelmann, and to the publication, *Plantæ Lindheimerianæ*, in which a large part of them were published and annotated. Various new species discovered by him bear his name, which is also commemorated by a peculiar genus of *Compositæ*, discovered by him. *Lindheimera Texana* is a very pretty Texan annual, which has remained in cultivation for nearly forty years, at least in botanical gardens; and a Mexican species has recently been made known, from the collections of Dr. Parry and Dr. Palmer. Hardly any name is more identified with the botany of his adopted State than that of the worthy Lindheimer. A. G.

CHARLES HENRY GODET, of Neufchatel, author of the Flora du Jura, died December 16, in the 83d year of his age. This venerable botanist and most estimable man was a very critical student of the European flora. He took a lively interest in that of our own country; so it is pleasant to remember that his name is borne by a peculiarly North American genus, containing over a dozen handsome annuals, mainly Californian, several of them prized ornaments of the flower garden. *Godetia* of Spach was reduced by Torrey and Gray and their contemporaries to a section of the genus (*Œnothera*) from which it was originally taken. But it has been restored by Sereno Watson, and it may be expected to hold its ground. It commemorates the services to science of a keen and sound botanist and a charming man. A. G.

3. *Das Microgonidium: ein Beitrag zur Kenntniss der wahren Wesens der Flechter:* von Dr. ARTHUR MINKS, Mittgl. mehr.

gelehrter Gesellschaften. Mit 6 colorirten Tafeln. 249 pp. 8vo. Basel, Genf. Lyon, (St. George's Verlag). 1879.—This work, noticed already by the present writer in this Journal, has happily at length made its appearance in very handsome form, and commends itself to all, at least to cryptogamic botanists. It is impossible to question either the care or the sincerity of the author; and if any views on the topic of this memoir demand attention from those qualified to consider them, certainly his do. Further notice must be postponed. E. T.

4. *Bulletin of the United States Geological and Geographical Survey of the Territories;* F. V. HAYDEN, Geologist-in-charge. Vol. v, No. 3, 331–520 pp. Washington, 1879.—This number contains the following papers: on the species of the genus Bassaris, by J. A. ALLEN: the American Bembicidæ; Tribe Stizini, by W. H. PATTON; list of a collection of aculeate Hymenoptera made by S. W. Williston in northwestern Kansas, by W. H. PATTON; further notes on the Ornithology of the Lower Rio Grande of Texas from observations made in the Spring of 1878, by G. B. SENNETT, edited by Dr. ELLIOTT COUES; additional lists of elevations, by HENRY GANNETT; generic arrangement of bees allied to Melissodes and Anthophora, by W. H. PATTON; annotated list of the birds of Michigan, by Dr. MORRIS GIBBS; the Coleoptera of the Alpine Rocky Mountain Region, part II, by JOHN L. LECONTE, M.D.

5. *Mittheilungen aus der Zoologischen Station zu Neapel,* zugleich ein Repertorium für Mittelmeerkunde. Vol. i, in 4 numbers. 592 pp. 8vo, with 18 plates. Leipzig, 1879. Wilhelm Engelmann.)

6. *Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge.* Vol. v, number 16. On the Jaw and Lingual Dentition of certain terrestrial Mollusks, by W. G. BINNEY. 331–368 pp., with 2 plates. Cambridge, 1879.

7. *Paleozoic Cockroaches: A complete revision of the Species of both Worlds, with an essay toward their classification;* by SAMUEL H. SCUDDER. 134 pp. 4to, with 6 plates. Boston, 1879. (Memoirs of the Boston Society of Natural History, vol. iii, part I, number 3).

8. *Insects from the Tertiary Beds of the Nicola and Similkameen Rivers, British Columbia;* by S. H. SCUDDER. (Geol. Survey of Canada, 1877–78.)

IV. ASTRONOMY.

1. *On the Secular Changes in the elements of the orbit of a Satellite revolving about a planet distorted by Tides;** by G. H. DARWIN.—The investigation which forms the subject of this paper is entirely mathematical, and is therefore not of a kind to be easily condensed into a short account.

This paper is the fifth of a series (of which notices have from time to time appeared in Nature) in which I have endeavored to

* Abstract of a paper read before the Royal Society, on December 18, 1879.

trace the various effects on the configuration of a planet and satellite, which must result from tidal friction—the tides in the planet being either a bodily distortion or oceanic. The investigations are, I think, not without interest as a branch of pure dynamics, but this side of the subject is too complicated to be made intelligible without mathematical notation, and it would occupy too much space to explain the methods of treatment.

There is, however, another side of the subject, which must, I think, attract notice, or at least criticism, and this is the applicability of the results of analysis to the history of the earth and of the other planets.

We know that no solids are either perfectly rigid or perfectly elastic, and that no fluids are devoid of internal friction, and therefore the tides raised in any planet, whether consisting of oceanic tides or of a bodily distortion of the planet, must be subject to friction. From this it follows that the dynamical investigations must be applicable to some extent to actual planets and satellites. For myself, I believe that it gives the clue to the history of the system, but of course an ample field for criticism is here opened.

The investigation is intended to be more especially applicable to the case of the earth and moon, and therefore, instead of planet and satellite, the expressions earth and moon are used.

The effect of tidal friction upon the eccentricity and inclination of the lunar orbit here affords the principal topic. The obliquity of the ecliptic, the diurnal rotation of the earth, and the moon's periodic time were considered in a paper read before the Royal Society on December 19, 1878, and which will appear in the Philosophical Transactions for 1879.

The present paper completes (as far as I now see) the main investigation for the case of the earth and moon, and therefore it is now possible to bring the various results to a focus.

It appears then, that when we trace backward in time the changes induced in the system of the earth and moon by tidal friction, we are led to an initial state which is defined as follows:—

The earth and moon are found to be initially nearly in contact; the moon always opposite the same face of the earth, or moving very slowly relatively to the earth's surface; the whole system rotating in from two to four hours, about an axis inclined to the normal to the ecliptic at an angle of 11° 45′, or somewhat less; and the moon moving in a circular orbit, the plane of which is nearly coincident with the earth's equator.

This initial configuration suggests that the moon was produced by the rupture, in consequence of rapid rotation or other causes, of a primeval planet, whose mass was made up of the present earth and moon. The coincidence is noted in the paper, that the shortest period of revolution of a fluid mass of the same mean density as the earth, which is consistent with an ellipsoidal form of equilibrium, is two hours twenty-four minutes; and that if the moon were to revolve about the earth with this periodic time, the surfaces of the two bodies would be almost in contact with one another.

pture of the primeval planet into two parts is a matter ation, but if a planet and satellite be given in the initial ition above described, then a system bearing a close nce to our own, would necessarily be evolved under the of tidal friction.

eory postulates that there is not sufficient diffused matter ially resist the motions of the moon and earth through Sufficient lapse of time is also required. In a previous howed that the minimum time in which the system could raded from one initial state, just after the rupture into es, down to the present state, if fifty-four millions years. e actually occupied by the changes would certainly be iger.

ears to me that a theory, reposing on a *vera causa*, which to quantitative correlation the lengths of the present day th, the obliquity of the ecliptic and the inclination and ity of the lunar orbit, must have considerable claims to ce.

stated that the periodic times of revolution and rotation oon and earth might be traced back to a common period two to four hours. In a previous paper the common as found to be a little over five hours in length; but that is avowedly based on a partial neglect of the sun's attrac- this paper certain further considerations are adduced, iow that, while the general principle remains intact, yet non period of revolution of the earth and moon must have been shorter than five hours to an amount which is i, but is probably large. The period of from two to four here assigned, because it is mechanically impossible for i to revolve about the earth in less than two hours, and ertain how the rupture of the primeval planet took place. tidal friction has been the agent by which the earth and ive been brought into their present configuration, then hanges must have been going on in the other bodies iake up the solar system. I will therefore make a few on the other satellites and planets.

first place it is in strict accordance with the theory, that i should always present the same face toward the earth. tz, was, I believe, the first who suggested tidal friction as e of the reduction of the moon's axial rotation to identity orbital motion. It is interesting to note in this connec- the telescope seems to show that the satellites of Jupiter, at least of the satellites of Saturn, also have the same ty.

rocess by which tidal friction brings about the changes in iguration of a planet and satellite is a destruction of or rather its partial conversion into heat within the planet, tial redistribution), and a transference of angular mo- from that of planetary rotation to that of orbital revolu- he two bodies about their common center of inertia.

Now a large planet has both more energy of rotation and more angular momentum; hence it is to be expected that large planets should proceed in their changes more slowly than small ones.

Mars is the smallest of the planets, which are attended by satellites, and it is here alone that we find a satellite revolving faster than the planet rotates. This will also be the ultimate fate of our moon, because after the joint lunar and solar tidal friction has reduced the earth's rotation to an identity with the moon's orbital motion, the solar tidal friction will continue to reduce it still further, so that the earth will rotate faster than the moon revolves.

Before, however, this can take place with us, the moon must recede to an enormous distance from the earth, and the earth must rotate in forty or fifty days instead of in twenty-four hours. But the satellites of Mars are so small, that they would only recede a very short way from the planet, before the solar tidal friction reduced the planet's rotation below the satellite's revolution. The rapid revolution of the inner satellite of Mars may then, in a sense, be considered as a memorial of the primitive rotation of the planet round its axis.

The planets Jupiter and Saturn are very much larger than the earth, and here we find the planets rotating with great speed, and the satellites revolving with short periodic times. The inclinations of the orbits of Jupiter's satellites to their "proper planes" are very interesting from the point of view of the present theory.

The Saturnian system is much more complex than that of Jupiter, and it seems partially in an early stage of development and partially far advanced.

The details of the motions of the satellites are scarcely well enough known to afford strong arguments either for or against the theory.

I have not as yet investigated the case of a planet or star attended by several satellites, but perhaps future investigations may throw further light both on the case of Saturn, and on the whole solar system itself.

The celebrated nebular hypothesis of Laplace and Kant supposes that a revolving nebula detached a ring, which ultimately became consolidated into a planet or satellite, and that the central portion of the nebula continued to contract, and formed the nucleus of the sun or planet. The theory now proposed is a considerable modification of this view, for it supposes that the rupture of the central body did not take place until it was partially consolidated, and had attained nearly its present dimensions.

I do not pretend, in these remarks, to have thoroughly discussed the cases of the other planets, and have only drawn attention to a few salient features; in the paper itself the subject is considered at greater length. It will, however, I think, be admitted that the theory agrees with some remarkable facts in the solar system.—*Nature*, Jan. 8.

2. *Earthquakes and the Planets.*—Mr. J. Delauney has presented to the Paris Academy of Sciences some new results

obtained from a study of Perrey's tables of earthquakes from 1750 to 1842. He finds two groups of Maxima, commencing in 1759 and 1756 respectively, each with a period of about twelve years; and two other groups, commencing in 1756 and 1773 respectively, with a period of about twenty-eight years. He remarks that those of the first two groups coincide with the times when Jupiter reaches the mean longitude of 265° and 135°; while those of the last two coincide with the times when Saturn reaches the same longitudes; whence he infers that terrestrial earthquakes have a maximum when these planets are in the mean longitudes mentioned. Delauney attributes the increased number of earthquakes in winter which Perrey has found to reach a maximum in November, to the passage of the earth at that time through swarms of meteors; and in like manner supposes the influence of Jupiter and Saturn to be due to their passing through meteor streams situated in mean longitudes 135° and 265°. As a consequence of this he ventures to predict an increased number of earthquakes in the years 1886, 1891, 1898, 1900, etc. C. G. R.

3. *The Problem of the Euripus.*—The tides in this narrow strait between Eubœa and the mainland of Greece, have from classic times been a scientific puzzle, for which a solution has been recently suggested by M. Forel, in a paper before the Paris Academy of Sciences. The currents through the strait are sometimes "regular" and sometimes "irregular." When "regular," the direction changes *four* times in the lunar day. When "irregular," the changes number from *eleven* to *fourteen* or even more in a lunar day. The current is "irregular" from the 7th to 13th and from the 21st to 26th day of the lunar month, or at the times of *quadrature*, and "regular" the rest of the time, or about the *syzygies*.

M. Forel attributes the "regular" tides to the ordinary tides of the Ægean Sea, which would be stronger at the syzygies. The "irregular" tides he thinks are due to *seiches* in the channel of Talauda (which forms a nearly closed lake to the northwest of Euripus), these prevailing over the weaker Ægean tides of the quadratures. From a ten years study of the seiches of Lake Leman, M. Forel has derived a formula to represent their time of vibration. This formula, ($t = \frac{2l}{\sqrt{gh}}$, in which $l =$ length and $h =$ depth of the lake), when applied to the channel of Talauda, whose length is 115 kilometers and maximum depth 200 fathoms, gives for the time of vibration 122, 100, and 86 minutes, according as the mean depth is taken at 100, 150 or 200 fathoms. These results agree well with the observation of eleven to fourteen tides per day, (which would give from 135 to 106 minutes for a single vibration), and would seem to confirm M. Forel's idea. C. G. R.

4. *The American Ephemeris and Nautical Almanac for the year* 1882. Washington, 1879.—In this volume of the National Ephemeris, Professor Newcomb has introduced several important changes, which were suggested by him and approved by a committee of the National Academy of Sciences.

The volume is now made to consist of three parts: 1st, the ephemeris for the meridian of Greenwich; 2d, the ephemeris for the meridian of Washington; 3d, predictions of phenomena to be observed, with data for their computation. The principal additions consist of the mean places of about 180 stars, making 383 in all, for the convenience of field astronomers, more complete data for eclipses, data about the transit of Venus, and largely increased information about the satellites of the planets.

5. *Auroræ: their Characters and Spectra;* by J. RAND CAPRON. F.R.A.S. 207 pp. 4to. London, 1879. (E. & F. N. Spon.)—The subject of the Aurora Borealis is one of popular as well as scientific interest, and this work by Mr. Capron not only presents it in a way to be entertaining to the general reader but also of great value to the scientific worker. After a few pages devoted to the historical part of the subject, the author goes on to describe in detail a number of specific auroral displays of especially remarkable character, and with them the various attendant phenomena. The latter half of the work is devoted to the discussion of the spectrum of the aurora, and the various magneto-electric experiments that have been made which tend to throw light upon its cause. The various theories that have been advanced to account for the aurora are mentioned. The book is published through the private liberality of Mr. Capron, and in respect to the number and beauty of the chromos and other illustrations deserves very high praise.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *United States Mensuration Surveys.*—The necessity for an organization in the Government to have charge and execution of all geodetic, geographical and topographical work of the whole country, in accordance with the recommendation of the Academy of Sciences to Congress at the last regular session, becomes more and more apparent the more closely the subject is studied. At the present time nearly all the States have their Geological Surveys so far advanced that nothing further can be done until these States are completely mapped by triangulation and topography on a sufficiently large scale. Such a survey is of great importance to every one owning an acre of ground; by it all boundary disputes could easily be settled; every farmer would have a complete survey of his farm, with all undulations of surface given and its relations to the adjacent farms, streams, woodlands and hills. There is no question that by the concentration of the classes of work referred to in one organization, with its unity of purpose and action, great economy would result in the execution of the work over a given area, with the certainty that every separate area so surveyed would ultimately join as a part of the whole with the accuracy attainable only by scientific processes of precision.

It is quite certain that large areas of the public domain, unfit for purely agricultural purposes, could be more economically and accurately surveyed, for purposes of sale, by triangulation than

the present system (so admirably adapted to agricultural ds), with the additional advantage of obtaining an accurate p without additional cost.

The triangulation part of the Geodetic Survey, with the reconssance for progressive work, executed by the Coast Geodetic vey now covers one-third of Maine, two-thirds of New Hampe, one-third of Vermont, one-half of Massachusetts, one-half of mecticut, two-thirds of New Jersey, one-quarter of Pennsylva-, one-quarter of Maryland, one-third of Virginia, one-quarter of rth Carolina, South Carolina, Georgia and Alabama, one-sixth of sissippi, one-sixth of Tennessee, one-fifth of Kentucky, one-tenth)hio, one-tenth of Indiana, one-tenth of Illinois, one-sixth of Misri, one-fifth of Wisconsin, one-sixth of Colorado, one-sixth of vada and Utah, one-fifth of California; and the triangulation of Lake Survey is complete along the American shores of Lakes ario, Erie, Huron, Michigan and Superior, and across Michi- between Lakes Erie and Michigan. By joining this smaller k with that first mentioned, there will be formed a complete is for the extension of the triangulation over every State and ritory except Alaska. It thus appears that no new organiza- is required, but simply the extension of one already in existe, familiar with the work, and conducted by experienced and led persons.

The ultimate cost of such a survey is sometimes stated as an ection to a system so complete, but this cost is greatly exagated in popular opinion. In the older States where many ails, such as houses, roads, clearings, villages and towns exist, average cost, as nearly as can be computed by past experie, would not, except in cases of the large towns, exceed seven its per acre. This expense should be divided between the Gen-l Government and the State, the Government executing the ingulation and that part of the topography required to deline- the characteristic forms of the country, including the streams; State to execute the remainder of the topographical detail uired for its own purposes. In such case the cost to the State uld not exceed three cents per acre. To this an exception st be made in cases of large towns, where the surveys might be uired on large scales; the cost would then be determined by scale of the work.

It is to be hoped, in consideration of the vast importance to the intry of a comprehensive survey of its area, that this session of ngress will not close without the passage of a law carrying ly into effect the plan recommended by the National Academy Sciences to Congress at its last regular session, meeting in this pect the just requirements of the public service, with a new parture and a new hope of increased usefulness to our whole ople. EDS.

. *The Arctic Voyages of Adolf Erik Nordenskiöld*, 1858-'9, with illustrations and maps. 447 pp. 8vo. London, 1879. acmillan & Co.)—The general interest that has recently been

excited by the remarkably successful voyage of Professor Nordenskiöld, around the north coast of Asia, cannot fail to have awakened a desire for further information in regard to his earlier Arctic explorations. This desire will be satisfied by the present volume, prepared by Mr. Alex. Leslie, of Aberdeen. It opens with an autobiographical sketch of Professor Nordenskiöld; then follow accounts of the Swedish Arctic Expeditions of 1858, 1861, 1864, 1868, 1873, also of the voyage to Greenland in 1870, in which the large masses of native iron were discovered, the voyages to the Yenissej in 1875, and again in 1876, and finally a partial account of the Northeast Passage expedition of 1878–1879, in the Vega. The accounts are intended to be popular, only occasional brief references to the scientific results of the expedition being introduced, but they are well written and fully illustrated. The book is a valuable addition to the many fascinating stories of Arctic exploration, and still more is a worthy tribute to one of the ablest explorers who has entered that perilous field.

3. *Chart of the Magnetic Declination of the United States;* by J. E. HILGARD. Washington, 1879. (U. S. Coast and Geodetic Survey, Carlile P. Patterson, Superintendent.—Appendix No. 21, Report of 1876.)—This chart of the magnetic declination of the United States for 1875, by Professor J. E. Hilgard, is mainly based upon the Coast Survey observations up to 1877, together with observations made under his direction at 200 stations between 1872–77, at the charge of the Bache Fund. In addition to these two principal sources, use has also been made of observations taken in various surveys by the U. S. Engineers and under the direction of the General Land Office. The reduction of the observations to a common date has been based on the researches of Mr. C. A. Schott on the secular variation of the magnetic declination in the United States.

4. *On the probable Temperature of the Primordial Ocean of our Globe;* by ROBERT MALLET, F.R.S., F.G.S.—According to the latest hypotheses as to the quantity of water on the globe, its pressure, if evenly distributed, would be equal to a barometric pressure of 201·74 atmospheres. Accordingly water, when first it began to condense on the surface of the globe, would condense at a much higher temperature than the present boiling-point under ordinary circumstances. The first drops of water formed on the cooling surface of the globe may not impossibly have been at the temperature of molten iron. As the water was precipitated, condensation of the remaining vapor took place at a lower temperature. The primordial atmosphere would be more oblate and less penetrable by solar heat than the present, and the difference of temperature between polar and equatorial regions would be greater; so that, in the later geological times, ice may have formed in the one, while the other was too hot for animal or vegetable life.—*Phil. Mag.*, Jan., 1880.

5. *How to Work with the Microscope.* 5th edition, enlarged and revised. 518 pp. 8vo. Philadelphia, 1880 (Presley Blak-

on, formerly Lindsay & Blakiston).—This work by LIONEL S. ALE, F.R.S., President of the Royal Microscopical Society, is invaluable contribution to the *English* literature on the microope. The well known 4th edition has been completely remoded; over 100 pages of new matter and 150 engravings have en added. The present edition is not only a text book but an cyclopedia of the microscope. Of the new material published e notice: (1) by Prof. Gulliver, F.R.S., 41 figures of plant cryss with original notes; (2) by Mr. Wenham, F.R.M.S., practical ggestions connected with the construction of object glasses; (3) r Mr. H. C. Sorby, F.R.S., additional matter on spectro-microopy; (4) by Mr. Frank Rutley, of the Geological Survey, conse, clear and admirable directions for the microscopic examina- rocks, minerals and fossils, illustrated by 39 figures. That rtion of the last edition on photography by Dr. Maddox, has en revised by Dr. Clifford Mercer, who mentions a number of cent improvements and adds a *complete* list of memoirs on the plication of photography to the microscope. The entire work ars evidence of much laborious care on the part of Dr. Beale in revision. It is eminently practical in its methods; a self-help the beginner and instructive to the more advanced student of e microscope. C. A. A.

6. *The American Monthly Microscopical Journal.* Editor d Publisher, ROMYN HITCHCOCK, F.R.M.S. Vol. i, No. 1, Januy, 1880. New York.—The new monthly is in fact a continuation f the Quarterly, which was previously carried on under the same ditor. The first number of twenty pages contains articles on ew species of Ophrydium; on the Amplifiers of Zeiss; on freshrater Algæ; on a method of making sections of insects and their ppendages; on the classification of Rhizopods; with also editorial notes, correspondence, etc.

7. *The School of Mines Quarterly;* Vol. i, No. 1, New York, 1880.—This new Journal is issued quarterly under the auspices of the Chemical and Engineering Societies of Columbia College. It promises to occupy a creditable position among undergraduate periodicals. The first number contains the following articles: The pedometer as a surveying instrument, by Prof. H. S. Munroe; Coffee and its adulterations, by F. Weichmann; Fire-brick and Terra cotta, by A. M'L. Parker; Chloral, by A. P. Hallock; Building Stones, I, by J. L. Greenleaf; with also notes on Mineralogy by C. A. Colton, E.M. and on Physics by M. C. Ihlsing, Ph.D.

8. *Catalogue of Diatomaceæ*, by FREDERICK HABIRSHAW, F.R.M.S. (New York: Romyn Hitchcock).—This catalogue is designed to be a complete index to all the published literature escribing or figuring the Diatomaceæ. It is stated that the speies will be arranged alphabetically, under the proper genera eferring to every description in chronological order. The work to appear in four parts in large octavo, and its unquestioned alue will doubtless be appreciated by all workers in this field.

9. *Treatise on Fuel, scientific and practical;* by ROBERT GALLOWAY, M.R.I.A., F.C.S. 136 pp. 8vo. London, 1880. (Trübner & Co.)—This little book contains, in a compact form, the more important facts in regard to the properties of the different kinds of fuels, their heating power and the calorimetric methods by which it is determined; also a chapter on pyrometers, and another on the Siemens regenerative gas furnace. The work is arranged with a view to being used in instruction, while at the same time valuable to the practical manufacturer.

10. *Petroleum.*—Mr. C. A. ASHBURNER, in a lecture in the Franklin Institute course, upon the subject of petroleum, stated that he estimated that Pennsylvania, from the discovery of oil by Col. Drake, in 1859, to the end of 1879, had produced in the aggregate 133,262,639 barrels of crude oil, from the sale of which the State has realized $340,709,672. The theory that the Pennsylvania oils are derived entirely from the decomposition of the vegetable and animal life of the Devonian age, and that the oil sands are but reservoirs holding the oil, Mr. Ashburner thinks established beyond a doubt by facts gathered from the oil miner.

OBITUARY.

ALEXANDER SADEBECK, Professor of Mineralogy at the University of Kiel, and author of many papers upon mineralogical subjects, died on the 9th of December, 1879, at the age of thirty-six.

Report of the Entomologist, Charles V. Riley, M.A., Ph.D. 52 pp. 8vo, with 7 plates. Washington, 1879 (Report of Department of Agriculture for 1878).

Journal of the Cincinnati Society of Natural History, vol. ii, no. 2, July, 1879. Contents:—Annual Address, by V. T. Chambers; notes on some new or little known North American Limnæidæ, by A. G. Wetherby; observations on birds, by Charles Dury and L. R. Freeman; description of twelve new fossil species and remarks upon others, by S. A. Miller.

Unser Sonnenkörper nach seiner physikalischen, sprachlichen und mythologischen Seite hin betrachtet von Dr. Schmidt, Rector in Gevelsberg. 60 pp. 4to. Heidelberg, 1877.

The Workshop Companion: a collection of useful and reliable recipes, rules, processes, methods, wrinkles and practical hints for the household and the shop. 164 pp. 12mo. New York, 1879.

The Palenque Tablet in the United States National Museum, Washington, D. C.; by Charles Rau. 81 pp. 4to. Washington City, 1879.

A Dictionary of the German terms used in Medicine; by George R. Cutter, M.D. 304 pp. 8vo. New York, 1879 (G. P. Putnam's Sons).

Report on the Meteorology of India, for 1877, by John Elliott. Third year. Calcutta, 1879. Quarto, pp. 230; appendix pp. 114.

Report of the administration of the Meteorological Department of India. Thin quarto.

Report on the Madras Cyclone of May, 1877, by J. Elliot, M.A. Meteorological Reporter to the Government of Bengal. Quarto, Calcutta, 1879.

Zoology for Students and General Readers, by A. S. Packard, M.D., Ph.D. 719 pp. 8vo, with numerous illustrations. New York, 1880, (Henry Holt & Company).

APPENDIX.

XXI.—*The Limbs of Sauranodon, with Notice of a new Species;* by O. C. MARSH.

E the first species of the present genus (*Sauranodon*
) was described by the writer,* eight other specimens of
e group have been discovered, and are now in the Yale
n. In three of these, the skull is preserved, but there
l no indications of teeth, so that we may consider these
as entirely edentulous. The skull shows many points
mblance to that of *Ichthyosaurus*. The vertebræ, also,
y similar to those in that genus.

e characters of the limbs, *Sauranodon* presents some fea-
f special interest. The anterior and posterior limbs are
veloped, and adapted for swimming. These extremi-
less specialized than those in any other known verte-
bove the Fishes.

e fore paddle, the humerus alone is differentiated. Be-
s, the bones of the forearm, the carpals, metacarpals,
alanges are essentially rounded, free disks, implanted in
mitive cartilage. The radius may perhaps be regarded
rtial exception, as its free margin is nearly straight, and
at thinner than the remaining border. There are three
f nearly equal size in the first row below the humerus.
dius may be identified with certainty by its position.
xt bone evidently corresponds to the intermedium, and
rd, or outer one, to the ulna. In the succeeding row,
re four subcircular bones, and five in the next series.
represent the carpals. There are six metacarpals, and
well developed digits, each composed of numerous
ges, which are all free, and nearly circular in form.

e posterior limb, the structure is essentially the same.
tal end of the femur has three distinct facets, and of
he middle one is the largest. Next below the femur,
iculating with it, are three bones which apparently rep-
the tibia, intermedium, and fibula, although the first
an be determined from its shape and position. The
w contains four rounded bones; and the succeeding one,

* This Journal, vol. xvii, p. 85, Jan., 1879.

five, as shown in the cut below. These correspond to the sals, and in the next series are the six metatarsals. There six digits represented in this specimen. The distal phala are small and circular, and are left unshaded, as their e position has not been determined.

1.

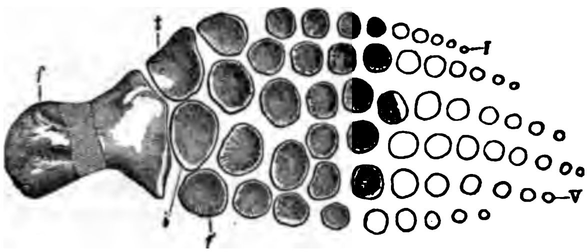


Figure 1. Left hind paddle of *Sauranodon discus*, Marsh; seen from b one-eighth natural size; *f*, femur; *t*, tibia; *i*, intermedium; *f′*, fibula; digit; *V*, fifth digit.

The above figure agrees essentially with the other pa preserved, and thus may be taken to represent the typical in this group of reptiles. The most striking features in Sauranodon limb are, the three bones articulating with femur, and the six complete digits. These characters ma stage of development below that seen in any other air-breat vertebrate, and only approached by the limb of *Ichthyosau* The transverse segmentation is distinct in the first five se regarding the humerus and femur as the first segment propodial bones.* If the three bones of the second series podials) are rightly interpreted, the middle one is the inte dium. Its position in the paddles of *Sauranodon* of both known species indicates that its true place is in the segr where it is found. If so, it follows that in the proces differentiation this bone has been gradually crowded out o original position between the marginal bones of the secon epipodial, series into the third, or mesopodial, where we find it.

* The need of general designations to apply to the corresponding segments of the anterior and posterior limbs of the air-breathing vertebrates is ev While we have the convenient terms "Phalanges" and "Metapodials" for th tal parts of the extremities, there are no names in use for the portions a Hence, the following are suggested:

		Anterior.	*Posterior.*
Propodial bones	=	Humerus,	Femur.
Epipodial "	"	Radius and Ulna,	Tibia and Fibula.
Mesopodial "	"	Carpals,	Tarsals.
Metapodial "	"	Metacarpals,	Metatarsals.
Phalangial "	"	Finger bones,	Toe bones.

In *Ichthyosaurus*, the intermedium is not entirely excluded from the epipodial row; in *Plesiosaurus* and all other reptiles the process is essentially completed. In some Amphibians, this bone still separates the lower ends of the two specialized bones above it. *Sauranodon* marks an earlier and most interesting stage in the differentiation, and, taken in connection with the examples here cited, indicates clearly how the transition was accomplished.

The six complete digits in the limbs of *Sauranodon* is a character not before observed in any air-breathing vertebrate. Some of the Amphibians retain remnants of a sixth digit, and *Ichthyosaurus* often has, outside of the phalanges, one or more rows of marginal ossicles that probably represent lost digits. With these exceptions, the normal number of five digits is not exceeded.

Sauranodon discus, sp. nov.

A comparison of the various specimens of *Sauranodon* now known indicates two distinct species, which may be distinguished as follows: the type species (*S. natans*) has the facial portion of the skull much elongated, and the snout slender. The vertebræ are short, and deeply concave, in fact, almost perforate. The head of the humerus is but very slightly convex. A second specimen, which agrees in its main specific characters with the type, has a subcircular coracoid, with but slight emargination.

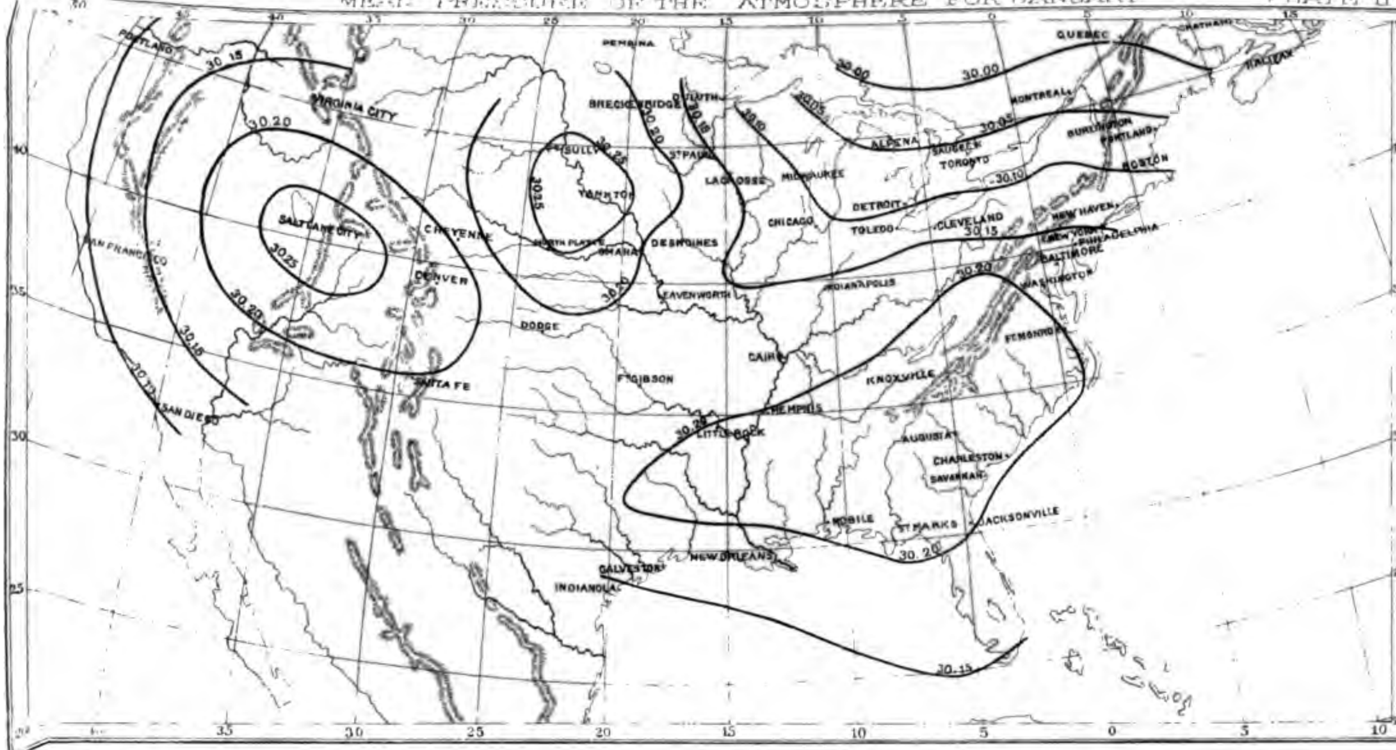
In the species here described, which is based upon the greater portion of a skeleton, the coracoid is more deeply emarginate, and the head of the humerus rounded, nearly as much as that of the femur. The paddles, also, are broader in proportion to their size, than in the type species, and other differences are apparent.

The present specimen indicates a reptile about twelve feet in length. It is from the upper Jurassic of Wyoming, and was found in the series of marine deposits which the writer has called the Sauranodon beds. This is a well marked horizon.

Yale College, New Haven, Jan. 24th, 1880.

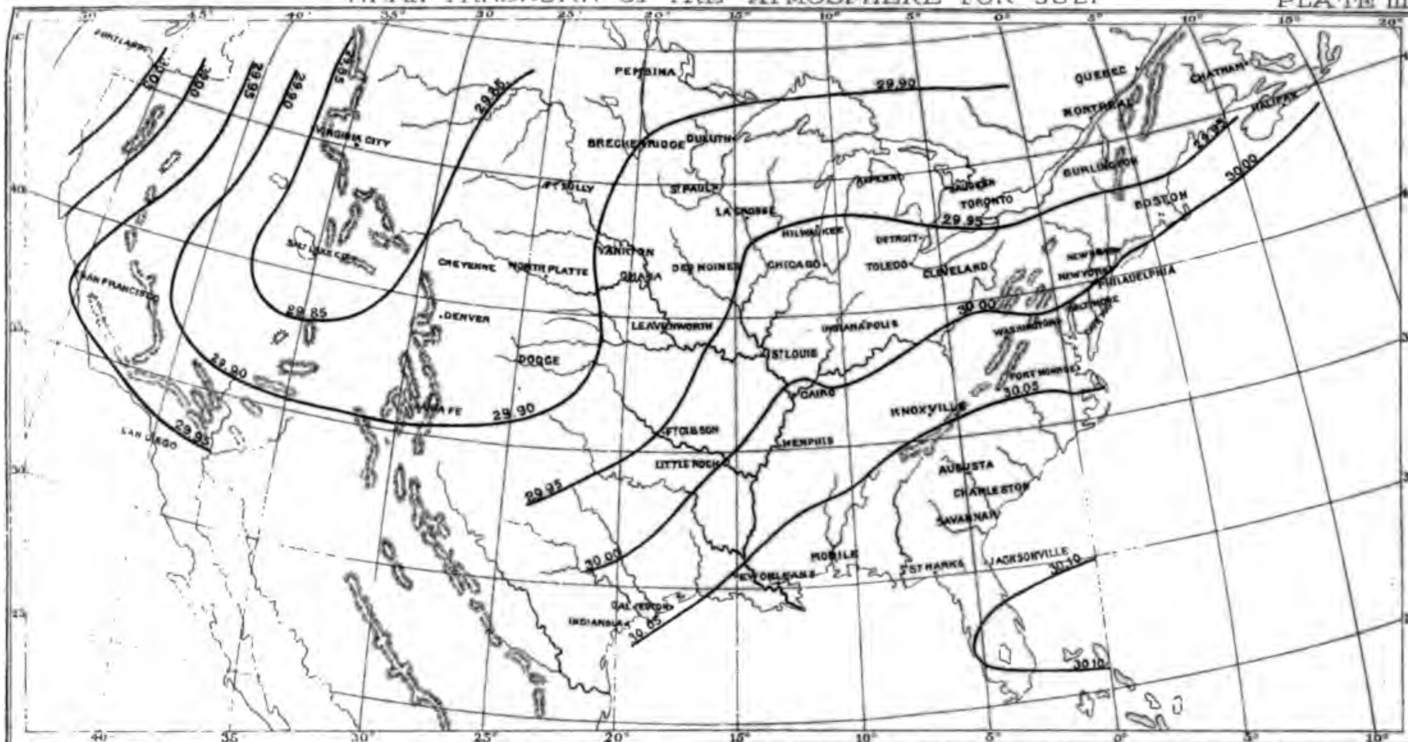
MEAN PRESSURE OF THE ATMOSPHERE FOR JANUARY

PLATE II



MEAN PRESSURE OF THE ATMOSPHERE FOR JULY

PLATE III



THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXII.—*On a Chart of the Magnetic Declination in the United States, constructed, by* J. E. HILGARD, Assistant U. S. Coast and Geodetic Survey. With Plate V.

[From the United States Coast Survey Report for 1876.]

SIR: I submit to you herewith, for publication in the Coast Survey Report for 1876, a chart of the magnetic variation in the United States. This chart, which shows the lines of equal magnetic declination (so-called Isogonic lines) for the year 1875, is mainly based upon the observations made during the progress of the coast survey up to 1877, together with those made under my personal direction during the period 1872–'77, at the charge of the fund bequeathed for scientific research by the late Professor Alexander Dallas Bache, held in trust by the National Academy of Sciences.

When the income of this fund became available for its objects, I proposed, in 1871, to the board of direction, then consisting of Professors Joseph Henry, Louis Agassiz, and Benjamin Peirce, that a portion of it should be devoted to the investigation of terrestrial magnetism in the United States, that subject being one in which Professor Bache had taken much interest, and in the investigation of which he had been personally engaged. Moreover, while this was a subject of general importance, there was not at that time any provision made for its prosecution on the part of the government. The board of direction having approved of my proposition, an allotment was made for several years in succession, and the observations were prosecuted under my immediate direction by observers whom

United States

... this way observations ... at about 200 stations ... interior country, at 150 of ... ontal intensity were also ... will be published in detail ... al Academy of Sciences.

... extension of the scope of the ... the interior country, you pro- ... requisite magnetic observations, the ... Bache fund deemed it best to close ... een carrying on, and to publish the ... most available form, beside printing the ... es as a matter of record. Such publica- ... effected by combining them with all similar ... and giving a graphic representation of the gen-

... accompanying map this has been done for the declina- ... variation of the compass) which is the element of the ... practical utility. Since the data obtained by the Coast ... form a very large part of the material used, an early publication in the Coast Survey Report is thought to be the most advantageous mode of giving the results to the country. The incessant demands made upon the office of the Coast and Geodetic Survey for information relative to the variation of the compass in different parts of the United States bear evidence of the appreciation in which is held the similar map given in the Coast Survey Report for 1865 and published in 1867. The present map cannot fail to meet acceptably the constantly-increasing demand, as it is not only brought up to a more recent date, but is based upon a very much greater number of exact observations in the interior.

In its construction I have made use of all available data up to 1877, including, notably, beside the two principal sources already mentioned, the magnetic observations made in connection with the surveys of the Great Lakes and those of the Northern and of the Northwestern Boundaries by the United States Engineers, and those made under the direction of the General Land Office in tracing some of the principal meridians and base-lines for the surveys of the public lands and the boundaries of some of the Territories. Moreover, some very valuable observations have been furnished by private observers, which will be specified in another place.

I am indebted to Mr. A. Lindenkohl, chief draughtsman in the Coast and Geodetic Survey Office, for his valuable aid in the graphic construction of the Isogonic lines.

It was fortunate that, for the construction of this chart, the researches of my colleague, Assistant Charles A. Schott, on the

tion of the magnetic declination in the United
ailable, without which it would have been diffi-
he observations to a common date, with some
racy. His latest paper on this subject, printed
e found very useful for reference.
rate publication, it will probably be convenient to
Schott's map, illustrating the annual change, on the
side of the chart of magnetic declination, in order to
he sheet available for use without the aid of an explana-
t.

J. E. HILGARD,
Assistant Coast and Geodetic Survey.

ARLILE P. PATTERSON, *Superintendent.*

oast and Geodetic Survey Office, Washington, D. C., July 1, 1879.

ENDUM.—The approximate annual change of the declin-
or the epoch 1880 in different parts of the country is
elow, as deduced from the map accompanying the val-
esearch on the secular variation of the magnetic declina-
the United States, etc., by C. A. Schott. Appendix
to Coast Survey Report for 1874, third edition, 1879.
observed amount of change is by no means the same
places not far remote from each other, as New York
iladelphia. In grouping together a table of the present
change much allowance must therefore be made for
e local peculiarities that have not been ascertained.
e interior States the information is very scanty, or
her wanting.
annual change is expressed in minutes of arc, a + sign
ing increase of westerly or decrease of easterly declination.

Locality.	Annual change.	Locality.	Annual change.
ast of	+2′	West Virginia	+3½
terior	+3	N. Carolina, S. Carolina, Georgia	+3½
npshire	+3½	Florida, northern part	+3½
	+5½	Florida, southern part	+3½
setts, eastern part	+2½	Alabama, Mississ., Gulf coast of	+3½
setts, western part	+3 to 4	Louisiana, eastern part	+3
land and Connecticut	+3½	Louisiana, western coast	+2
k, Long Island	+2½	Texas, coast of	+2
rthern and west'n part	+4½	Texas, southwestern part	0
sey	+3	Colorado	+2½
ania	+3½	Utah	+ ½
	+2½	New Mexico and Arizona	0
e, eastern part	+2½	California, coast of	−1½
e, western part	+2	Oregon, coast of	−2 to 2½
	+2	Washington Territory, coast of	−2½ to 3
, Maryl'd, and Virginia	+3		

negative sign indicates an increase of easterly declination.

J. E. H.

ART. XXIII.—*The Old River-beds of California*; by JOSEPH LECONTE.

[Read before the National Academy of Sciences, Oct. 29, 1879.]

OLD river-beds are found in nearly all countries which have been affected by drift-agencies. In nearly all such countries, too, these old beds are filled to great depths with river deposit. But the old river-beds of California are in several respects entirely unique. In most other countries, as for example, in Europe and Eastern United States, the new or present river-beds occupy the same position as the old; while in middle California the rivers have been *displaced*, by lava flows, from their former position and compelled to cut entirely new channels. Again: in certain portions of Europe and in Eastern United States, the old river-beds are broad, deep troughs, filled sometimes several hundred feet deep with detritus, into the upper parts of which the present much shrunken streams are cutting their narrower channels on a *higher* level; while in California the displaced rivers have cut their new channels 2000 to 3000 feet deep in solid slate, leaving the old detritus-filled channels far up on the dividing ridges. In northeastern United States the drainage system has remained substantially unchanged since early Tertiary, or even still earlier times; while in middle California the Tertiary drainage system seems to have been obliterated and the streams have been compelled to carve out to a much deeper level an entirely new and independent drainage system, having the same general direction but often cutting across the former. In the one case the old beds *underlie* the new, while in the other they *overlook* them from the tops of the neighboring ridges. Furthermore, in California the detritus which fills the old river-beds is nearly always capped with lava or other volcanic material, clearly indicating the cause of the displacement. If to all these peculiarities we add the usually extreme coarseness of the detritus which fills the river-beds of California, consisting as it does largely of pebbles and bowlders, compared with the fine silts which fill the old river channels of the Eastern coast, and we will see how marked is the contrast in many respects.

For all that is known concerning the old river-beds of California, we are up to the present time almost wholly indebted to Professor Whitney. His valuable investigations on this subject were published in the first volume of the Geological Survey of California in 1865. He has also recently published a fuller description and a complete map of them. His views have therefore been before the scientific public for many years, and are so well known that a bare enumeration of their main

features is all that is required here. Whitney shows: 1. that there is in California an old river-system entirely different from the present river-system; 2. that the old channels were filled by detritus, and the detritus covered by lava-streams; 3. that the lava flows, completing the filling of the channels, diverted the streams and forced them to cut for themselves new channels; 4. that the displaced streams cut their new channels to a much lower level than the old, so that these latter are now found on the present divides. My own observations entirely confirm these results, and they form therefore my starting point. Whitney also regards the old detritus as the representative of at least the whole Pliocene and the Lava flow as its closing event. In what respects my own views are an extension of Whitney's, and in what respects they differ from them, will be sufficiently indicated in what follows.

The general relation of the old and the new beds is well shown in the following figures taken from Geological Survey of California. In figure 1 the old and new beds are parallel, and the section is across both; while in figure 2 the new beds have cut across the old, and the section is along the old and across the new.

This peculiar relation of the old to the new river-beds does not characterize the whole Pacific slope, but only the auriferous slate belt of middle California. It is not found in the Coast Range, nor in the region of the granite axis of the

1.

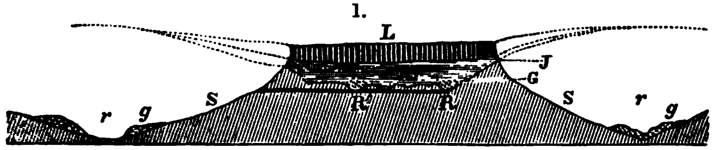


FIG. 1.—Section across Table mountain: *L*, lava; *SS*, sandstone;* *G*, old gravel; river-bed; *S*, slate bed rock; *r*, present river; *g*, present gravel.

2.

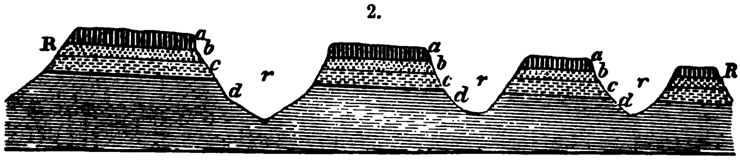


FIG. 2.—Lava stream cut through by modern rivers: *aa*, basalt; *bb*, volcanic ashes; *cc*, Tertiary; *dd*, Cretaceous; *RR*, direction of old river-bed; *rr*, of new river-bed.

Sierra Range. Neither is it found, at least in any marked degree, in extreme northern California nor in Oregon, nor yet in southern California. It seems to be confined mainly to the slate belt of the western slope of the Sierra from Plumas

* The material here called sandstone is a cemented river sand. It is usually covered with tufa or tufaceous conglomerate and this latter with lava.

county on the north to Tuolumne county on the south inclusive, a distance of about 250 miles, and from the San Joaquin and Sacramento plains on the west to about 4000 feet elevation on the Sierra slope on the east, a breadth of about 35 miles.

There is no problem in California geology more important, and yet none more difficult—none more enticing and yet none more baffling—than the mode of filling of the old river-beds and the cause of the displacement of the streams. The opportunities of study are abundant, for in many places the old beds have been bared, and complete sections of their fillings made by the operations of hydraulic mining; but the phenomena are so extremely complex and difficult of interpretation that we are not yet prepared for a final theory. I have on several occasions utilized my vacations by the study of these old channels and their fillings. In 1877 I examined those about Forest Hill; in 1878 those in Tuolumne county. Very recently under the intelligent guidance and kind assistance of Mr. Hughes, the superintendent of the Blue Tent mines, I have made a more extended and thorough examination than ever before. Extensive gravel deposits exist on both sides of the South Yuba River for many miles. This is in fact the finest mining region in the State. I went up one side and down the other and examined these in succession. I wish now to very briefly present the conclusions to which I have provisionally come by much reflection on the observations made on this and on previous occasions. I present them with some misgivings, well knowing that much more complete and detailed observations are necessary before an entirely satisfactory theory can be reached.

General Description.

It is well known that in hydraulic mining the whole thickness of the old river-channel-fillings is worked down and carried away by the prodigious force of the hydraulic jets. In such a mine, therefore, we always have the old bed bared over the whole area cleared, and the fillings exposed from bottom to top, on the face of an ever-receding vertical cliff 200 to 400 feet high.

The Bed.—The old stream-bed thus exposed has a shallow, trough-like form, i. e. is lowest in the middle and rises gently on both sides. These higher sides of the trough are called the "*rims.*" The *bed-rock*, which is usually slate with nearly vertical cleavage, retains usually its original soundness and hardness, but in some places is more or less decomposed, and sometimes, while retaining its form, is completely changed into plastic clay. In all cases it is worn into irregular and fantastic hollows and channels, and often into deep pot-holes. As there is no apparent relation between the hardness or softness of the

bed-rock and the amount of wear, it is certain that the softening has taken place since the filling. The surface-forms of the bed-rock are precisely such as are always produced by swift currents carrying coarse materials—precisely such as are *now* produced in the artificial channels through the rim-rock by the rushing torrents loaded with pebbles and gravel, resulting from the incessant play of the hydraulic jets against the cliff.* There can be no reasonable doubt, therefore, that these trough-like depressions are really the old channels of rushing torrents loaded with eroding materials.

The general form of the wide, shallow, trough-shaped channels of the old rivers is in marked contrast with the deep, sharply V-shaped cañons which characterize the present rivers in the same region.

The filling.—The cliff exposed by hydraulic mining, consists usually from bottom to near the top, of distinctly but irregularly stratified material. The lowest portion next the bed-rock, sometimes a few feet, sometimes many feet in thickness, is a conglomerate of pebbles and bowlders often of large size, with a paste of sand and plastic clay usually of a slate-blue color. This is the "*Blue gravel*" of the miners. The pebbles and bowlders are usually well rounded ("wash gravel"), but in a few channels I have found them sub-angular, like those of *till*. Above the Blue gravel, the whole way up to near the top, the material consists of alternate layers of pebbles, gravel, sand and clay, usually of a yellowish or reddish color. The pebble layers occur in lenticular masses, and the sands and clays are often cross-laminated. In many cases the whole material is more or less firmly cemented by lime carbonate or by silica, so that the cliff must be loosened by blasting before it can be washed down by the hydraulic jets. Irregularly distributed throughout the whole mass are found fragments or sometimes large trunks of drift timber, oak, maple and conifers, in a lignitized or else in a slicified condition. In some cases the lignitizing change has progressed but a little way. I found at Sailor's flat, beneath the volcanic cap, to be presently described, logs of Redwood (Sequoia) or of cedar (*Libocedrus*) probably the latter, in which the bark was still tough and fibrous although the wood was soft and could be cut like cheese. In the finely stratified sands and clays are found beautiful impressions of leaves of many kinds. According to Lesquereux these leaves indicate a Pliocene age for the deposits. More rarely mammalian bones have been found. Among these are allies of the rhinoceros, hippopotamus and camel, indicating, like the leaves a Pliocene age, but also in many undoubted cases the mam-

* It is well to note here the prodigious rapidity of this erosion. In the North Bloomfield mine, the pebble-loaded torrent, working eight months per year, has cut in four years a channel three feet wide and fifty feet deep in solid slate.

moth, the great mastodon and a tapir, undistinguishable from the living species, indicating a Quaternary rather than a Pliocene age. These Quaternary remains have been in several instances found under the volcanic caps in the lowest blue-gravel, next to the bed-rock. Several examples of this kind are now in the museum of the University. Some human remains and implements are also supposed to have been found in this detritus, but the authenticity of these is disputed by many.

In several cases I observed in the vertical cliff of detritus distinct curved lines of discontinuity, concave upward, indicating sub-channels cut in the main mass of detritus. Undoubtedly the main channel had been first filled, then partly swept out by erosion, and then re-filled. This observation is important, as it seems demonstrative of a true river agency.

The lower portion of the detritus, the so-called blue gravel, differs from the upper portion partly in structure, but chiefly in color. In structure it is almost if not quite devoid of lamination; and when the rock fragments are sub-angular it is almost undistinguishable from true *till* or ground-moraine. In most cases, however, its pebbles and bowlders are perfectly rounded. Its blue color is undoubtedly due to the fact that its iron is in the form of ferrous instead of ferric oxide. There is no such line of demarkation between the blue and the red gravel as would indicate a different origin. On the contrary the irregularity of the plane of contact and the shading of the color shows a downward progressive oxidation of iron, greater in some places than in others.

The capping.—Above the detritus which constitutes the main portion of the filling of most of the old river-beds, we nearly always find a capping of volcanic matter 50 to 150 feet thick. This is sometimes hard basalt underlaid by tufaceous conglomerate, but more usually tufaceous conglomerate only.

3.

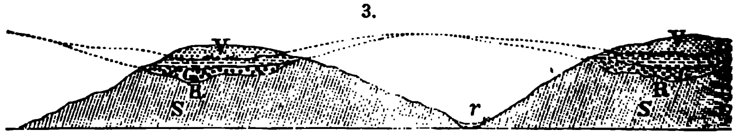


FIG. 3.—*SS*, slate bed rock; *RR*, old river bed; *r*, present river bed; *GG*, old river gravel; *VV*, volcanic conglomerate.

In this latter case, however, the presence of scattered blocks of basalt on the surface often indicates the *former* existence of a thin basaltic cap which has been removed by erosion. When a basaltic cap remains it gives rise to flat table-topped ridges as in figures 1 and 2. Otherwise the ridges become rounded by erosion. Figure 3 is an ideal section showing the more usual form. When the cap consists of tufaceous conglomerate above, the whole thickness of the filling, including the

volcanic cap, may be washed down together by hydraulic process, although the latter is of course barren matter; but when the cap is basaltic the auriferous gravel can only be worked by the slower process of drifting. In this case only the lower portion is extracted. In all cases the volcanic cap, especially the tufa, has furnished down-percolating, alkaline waters holding silica in solution. The condition of greater or less saturation (with perhaps other conditions)* seems to have determined whether this solution deposits or takes up silica. When it deposits, the gravel is cemented and the drift-wood is petrified; when it takes up silica the volcanic and slate pebbles are rotted down to "*putty stones*" and the bed rock is softened to a greater or less depth.†

The tufaceous conglomerate which is so constant an attendant of the old river gravels consists of a soft, earthy, reddish tufa, enclosing rounded pebbles of all kinds, volcanic, slate and quartz and of all sizes, distributed more or less abundantly but irregularly through its mass. It is probably volcanic ashes washed down from the higher Sierra slope by rain and melting snow. But the absolute absence of the least trace of stratification (which I sought for in vain) seems to show that the quantity of ash in proportion to water was so great that it was literally a mud-flow gathering pebbles in its course. In some cases, however, are found alternate layers of gravel and tufa. Where the basaltic lava occurs it always nearly overlies the tufa.

Nearly all the higher parts of the country are covered both with the gravel and with the tufa. The lava is also very widely spread. The indications are that these materials formed at one time an almost universal covering, but subsequent erosion has left them in ridges and patches.

Explanation of the phenomena above described.

There are many difficult and important questions suggested by the phenomena above described which press upon us for solution. "How were the old river beds filled with detritus?" "How were the streams displaced from their old beds?" "Why have the new channels been cut so much deeper than the old?" "When did these events occur?" I shall take these four points in the order mentioned.

1. *The mode of filling of the old river-beds.*—There are three possible modes in which we may conceive these beds to have

* In silicification of wood there is little doubt that the percolating alkaline waters charged with silica are neutralized by the acids of organic decomposition, and the silica thus rendered insoluble is deposited then and there (see author's Elements of Geology, p. 193.)

† In many of the hydraulic mines, especially in the Dardanelle mines near Forest Hill, I found in certain parts all the slate and volcanic pebbles while still retaining their form perfectly, reduced to a soft soapy bluish clay. These are called putty stones. It is evident their silica has been extracted by alkaline waters.

been filled with detritus. 1st. They may have been filled by glaciers slowly and steadily retreating up the valleys, dropping their debris on their way, the debris perhaps afterwards modified by currents from the melting glacier. 2d. They may have been filled successively from mountain foot toward mountain crest with detritus brought down by the rivers into a bay or fiord which steadily moved up the valley by subsidence of the land until the sea stood 4,000 feet above its present level. Or 3d, they may have been filled in all parts nearly simultaneously by true river action in the same way as river-channels elsewhere have been or under certain conditions are now filled.

I shall not discuss the first and second. I mention them because each, but especially the second, has been held by some persons. I have kept them constantly in mind during all my observations but have been compelled to abandon them as untenable. I am quite sure that no one can examine these deposits carefully without being convinced that they are true river deposits, though formed, certainly, under very exceptional conditions. It is these conditions which I now wish if possible to realize in imagination.

That the conditions were really exceptional is very evident on a little reflection. The present rivers in all this region run with high velocity, have cut very deep channels and are still cutting: why then should the former rivers in the same region have *filled* up instead of cutting their channels? The difficulty is not removed by supposing a lower velocity; for the character of the deposits, especially the great bowlders, often many tons weight, show a much higher velocity than now exists. With such rushing torrents why did the beds fill up instead of cutting deeper? To this I answer: any current, however swift, will deposit if *only its load be sufficient.* Every current has a certain amount of energy, and can therefore do a certain amount of work, increasing of course with the velocity.* This energy is usually divided between the work of transportation and the work of erosion. If the load of transported matter be moderate, a large amount of energy is left over for erosion; but if the load of transported matter be very great, the whole energy may be expended in transportation and none is left for erosion—the limit is reached at which erosion ceases and deposit commences. Now, since transported detritus is the main erosive agent, it follows that in every stream there is a certain amount of detritus which produces the maximum erosion. Pure water has little effect for want of erosive agent: too much material also produces little effect, because too much energy is consumed in carrying.

It is evident therefore that all that is necessary to cause any stream to deposit is to increase its load beyond the

* Gilbert, this Journ., vol. xii, pp. 16 and 85, 1876.

limits of its energy. This principle is well understood by hydraulic miners. The amount of water gathered in the sluices from the hydraulic jets must be duly related to the amount of earth removed. If the water is in excess, the precious water is wasted and the erosion of the sluices is very great; if the earth is in excess the sluice is choked, even though the velocity under proper conditions is sufficient to carry bowlders of several cubic feet. The water must be *well-loaded* but not *over-loaded.* The same important principle is well illustrated by the phenomena of the floods of the tributaries of the Sacramento River. As I learn from my nephew, Julian LeConte, who has been engaged in the hydrographical survey of this river, at the time of flood, the rushing waters first come down Feather River bringing only fine silt and clay; the water rises and increases proportionally in depth. Next comes the great mass of coarse sediment, sand, gravel and pebbles creeping slowly along the bottom and filling up the bed twenty feet deep; the water though in full flood is but little deeper (though much wider) than before the flood.* Lastly, as the water falls and has less sediment to carry, it again takes up the sediment previously deposited and scours out the channel even though its general velocity is now far less than when the same was deposited. In this case the filling is not permanent; but cases are not wanting of steady building up by rivers of very high velocity. According to the authority already mentioned the Yuba River at Marysville has permanently filled up its beds 30 feet deep, and 15 miles above Marysville 115 feet deep, in the last 30 years. This is wholly due to the large increase of transported matter produced by the operations of hydraulic mining. Again, according to Captain Dutton,† the Colorado River through its cañon and the Platte River over the plains have about the same slope, viz: eight feet per mile; but while the Colorado has cut its wonderful cañon and is still cutting, the Platte has filled up its channel and is still filling. The sole difference is the amount of load carried; the Colorado is *under*loaded, the Platte *over*loaded.

It is evident therefore that river deposits cannot, like ocean and lake deposits, be taken as a measure of time. Rivers either erode or build up by deposit. If they build, they almost always build very rapidly; for the carrying power of running water varies at so high a rate that a very slight change in conditions affects enormously the amount of deposit. While they build, therefore, they build rapidly but are liable under even very slight change of velocity or amount of sediment to scour out again. For example, Feather River fills up 20 feet in a single flood and scours out again when the flood subsides.

* The rise of the surface is about 23 feet; the filling of the bed 20 feet.

† Nature, vol. xix, p. 274, 1879.

But if the overloaded condition be permanent or habitual, then the building is permanent as well as rapid. For example, the Yuba River above Marysville has built up 115 feet in 30 years. I believe that most thick river deposits, whether of the present or of previous epochs, have been made in comparatively short space of time.

Now the phenomena of the old river-gravels, as I have described them, are precisely those of deposits made by the turbulent action of very swift, shifting, overloaded currents; only in this case the currents must have been far swifter and more heavily loaded than any existing currents. The detritus of the old river beds is usually exceptionally coarse; therefore the rivers at the time of deposit must have been exceptionally rapid; and therefore also the quantity of material necessary to overload them must have been exceptionally great; and therefore finally the process of filling was probably exceptionally rapid. It might have occupied years, or even centuries, but was geologically a very rapid process. Now I cannot conceive how all these conditions could have been fulfilled, except by the rapid melting of extensive fields of ice or snow. But why —it will be asked—was the detritus not carried away again? I answer: Because immediately after the filling was completed the detritus was protected and the rivers displaced by the lava-flood. This brings me to the next question, viz:

2. *The cause of the displacement of the rivers.*—As already shown, the mere filling up of the river channels with detritus alone would never have displaced the streams. On the contrary, as soon as the conditions determining the filling were changed, the rivers would immediately have commenced cutting into the detritus as they have done on the Eastern coast; and, on account of the high slope of their channels, would ere this have completely swept it all out, as they have done in Southern California. The protection of the detritus and the displacement of the streams is due wholly to the lava flood.

Middle California lies on the southern skirt of the great lava-flood of the Northwest.* The center of the great outflow was the Cascade and Blue Mountains. In Oregon the lava is 3,000 feet thick and therefore completely conceals the previous surface configuration of the country. In extreme northern California it is still a universal mantle several hundred feet thick, and therefore the old river beds with few exceptions are hopelessly concealed. In Middle California we find it reduced to ridges and patches by erosion, but originally it probably was even here a nearly universal mantle, covering the whole surface, except some highest points, and substantially obliterating the drainage system. But yet this lava mantle was not so

* See article by the writer on this subject in this Journal, vol. vii, p. 167, and p 279, 1874.

hick but that subsequent erosion has cut through the *thinner* arts, i. e., on the previous higher ground. Immediately after he obliteration of the previous drainage system, the rivers, of ourse, commenced cutting a new system, having the same eneral trend (for this is determined by the geneıal mountain lope), but wholly independent of, and therefore often cutting cross, the older system. Furthermore the streams in forming heir new beds seem to avoid the places of the old beds, for here the lava would be thickest, and cut their channels on the ld divides for there the lava was thinnest and therefore soonest emoved by general erosion, or perhaps was absent altogether.

Again: we have already seen that the rush of overloaded vaters which filled the old river-beds with detritus, could have een produced only by rapid melting of snow and ice. We ave seen also that the process of filling must have been comaratively rapid. Still further we have seen that the detritus nust have been quickly protected and the streams diverted y the lava-flow. Bearing these things in mind we are natually led, nay we are almost driven, to the conclusion that the pproach of the subterranean heat of the impending lava-flow was the cause of the rapid melting of the snow and the consequent rush of the overloaded waters which filled the channels with detritus. Before the melting was completed the ash-erupions had already commenced, and mud-streams, followed by ava-streams, completed the work of obliteration. We see preisely the same phenomena on a *small scale*, in the destructive loods and mud-streams which precede and accompany the ruptions of volcanos like Cotopaxi, whose summits are caped with perpetual snow. In the case we are discussing, howver, instead of a volcanic peak, a great mountain range overed with snow, erupted.

Some geologists of the Uniformitarian school, may object to he foregoing views, as savoring too much of Catastrophism. In nswer I would remark that it is simply impossible to account or wholesale obliteration of a river system except by somehing like a catastrophe. Powell and Dutton* have shown that of all geographical features, river courses in elevated regions re the most permanent. In early Tertiary times the Green River was winding its devious course southward when the Uinta Mountains commenced to rise directly athwart its pathway; but the river maintained its level and its course by cuting downward in proportion as the mountain rose upward. Farther south the Colorado plateau commenced to rise; but he river still maintained its level and its course by cutting lownward in the same proportion. When once a river, as it were, bites in and gets a grip upon the rocky bones of the

* Powell, Exploration of Colorado river, p. 152; Dutton, Nature, vol. xix, p. 247 and 272, 1879.

country it does not easily loose its hold. Rivers with deep channels like those of California will not change. Their channels must be obliterated, and then they make new channels. Such obliteration can only take place by submergence and prolonged sedimentation or else by a lava-flood.

We have seen that tufaceous conglomerate usually underlies the basaltic lava and covers the detritus even where the lava is wanting. It is evident therefore ash eruptions preceded the basaltic flow. The washing down of these ashes as mud streams completed the filling and then the lava flood covering all prevented the re-cutting of the channels in the same places. Furthermore, if we imagine the ash flood as even more general than the lava flood, it is easy to see how the new channels would commence between the lava streams, i. e., between the old stream beds, and once commenced would continue to cut in these places.

King* has drawn attention to the fact that in the same locality and therefore presumably from the same subterranean igneous reservoir *acid* eruptions immediately precede *basic* eruptions. He accounts for this order by supposing a gradual separation, by gravity from the same fused magma, of a lighter, acid, less fusible portion as a sort of scum on the surface of a denser, basic, more fusible portion. Eruption would of course commence with the ejection of the upper, acid, and finish with the lower, basic, portion. The eruptions of which we have been speaking seem to confirm this idea. The imperfectly fused, or aqueo-igneously fused, upper and more acid portions were ejected first as *ashes* and only later the igneously fused, basic, bottom portions were ejected as basaltic flows.

The conditions necessary to produce the double system of river-channels are peculiar and found only in the Sierra range of Middle and Northern California. In extreme Northern California and especially in Oregon the lava flood is so thick that the buried old river system is not revealed by erosion—the present rivers are running far above the old rivers. In Southern California on the contrary the rivers have never been displaced by lava, for the lava flood did not reach so far. If these channels were ever filled with detritus, this has not only been swept out again, but the rivers have continued to deepen their channels even to the present time. The double river system of Middle California is the result of the fact that this part lay in the extreme skirts of the great lava flood. In British Columbia beyond the limits of the lava flood, the relation of the new to the old river beds, as I learn from Mr. Amos Bowman, is again like those of the Eastern States. The rivers are now cutting into the detritus which fills the broader and deeper channels of the old rivers.

* Exploration of 40th Parallel, vol. i, Systematic Geology, p. 715.

3. *Why the modern rivers have cut to a lower level.*—I have already in a previous article* given reason to believe that the great lava flood of the Northwest came not from craters but from great fissures, and that the force of eruption was not the pressure of elastic gases merely, but also the lateral squeezing by which mountain ranges are elevated. It is almost certain, then, that coincident with the outflow of lava in California there was an increase in the elevation of the Sierra range. The inevitable effect of this would be the cutting of the new channels below the level of the old, and thus finally the singular relation between the old and the new channels which now exists.

There is a certain definite relation between the slope and the amount of detritus which determines the depth of the cañons. If this relation be disturbed by increase of slope, the stream will strive to reëstablish it. All deep cañons have been cut in rising ground and for the purpose of reëstablishing this relation. Thus it has been with the great cañons of the plateau region; thus also with the cañons which trench the eastern slope of the Colorado Mountains; and thus it must have been with the cañons of the Sierra Nevada. Again there is a certain relation little understood, between rain-erosion and stream-erosion. In Tertiary times we may imagine the conditions were favorable for general rain-erosion and unfavorable for stream-erosion or cañon cutting; and the result was a system of broad, shallow, trough-shaped channels with low divides. Since glacial times, on the contrary, the conditions have been favorable here for cañon cutting. Among these conditions the slope is certainly most important. It is difficult to imagine that the Tertiary river channels should have remained so shallow after the erosion of the whole Cretaceous and Tertiary times, if the general Sierra slope were as high *then* as it is *now*, viz: 100 to 200 feet per mile. It is true that the great glaciers of glacial times have probably greatly assisted in cutting the present cañons; but this would only affect the amount of time required, not the final result; for if glaciers cut deeper than streams would have done, these streams would again fill up their channels until the proper relation was again established.

The elevation which I suppose took place in the Sierra range at the time of the lava flow, was evidently of a gentle kind, unaccompanied with crumplings and dislocations of the strata, and therefore undetectable except by the work of cañon-cutting. The axis of the Quaternary elevation on the eastern portion of the continent was probably along the valley of Mississippi River; the axis on this side was the crest of the Sierra, where it gave rise to fracture and outflow.

The places where the lava emerged have not been found with certainty. It was probably along or near the crest, where the

* This Journal, vol. vii, p. 177, 1874.

subsequent erosion has been so great that the evidences are mostly obliterated. In Alpine County, about Silver Mountain and about Markleeville, the Sierra crest is formed largely of volcanic rocks. From this region probably a large number of streams radiated. But over the larger portion of the high Sierra erosion has bitten so deep that the lava streams have been entirely removed. I have however observed many dioritic, doleritic and felsitic dikes in all the granite region above the lava flow. These I have thought are probably the exposed roots of the flow.

4. *The age of the old river gravels and of the lava flow.*—Whitney and Lesquereux, on the evidence of the organisms, especially the plants, refer the gravels to the Pliocene, and regard them as representing at least the whole of that epoch, and the lava flood as its closing event. My own conclusion differs a little from this. I have already shown that the accumulation of the gravels and their protection by the lava flow may be regarded as geologically almost simultaneous. I now add that these two events closed the Pliocene and inaugurated the Quaternary.

As already seen, the *mammalian* remains are a mixture of the characteristic Pliocene species still lingering and of characteristic Quaternary species just coming in. They undoubtedly therefore indicate a transition from Pliocene to Quaternary, and whether on these evidences we refer the gravels to late Pliocene or early Quaternary will depend upon whether we regard as the more important test of age, the extinction of old or the introduction of new species. The evidence from human remains and implements, if these be regarded as authentic, is certainly on the side of greater recency. The *Plants*, it may be admitted, are Pliocene. But plants are far less delicate tests of age than mammalian animals: for not only are they, by their lower organization, less sensitive to changes of the environment; but being incapable of voluntary migrations, they are often compelled to linger beyond the epoch to which they belong. It is natural to suppose, therefore, that the Pliocene flora would linger even into the Quaternary until destroyed by the extreme rigor of glacial climate, or else by some catastrophe like that of the lava flood.

Again: the general phenomena of the gravels and the manner of their accumulation, as I have explained them, are wholly those of the Quaternary period. They can hardly be explained except by the existence of glacial conditions. Also the gentle movement of elevation which we have supposed preceded and attended the lava flow is characteristic of the Quaternary everywhere. It is probable, therefore, that the gradual elevation and the attendant glacial conditions commenced and advanced until the former culminated in fracture and outflow of lava.

But on the other hand, it is certain that the Pliocene passed insensibly into the glacial epoch, and therefore that glacial conditions commenced in the Pliocene. Furthermore, it is certain that here in California glacial conditions continued and reached their acme *after the lava flow;* for glaciers occupied all the present cañons,* and *swept away all the lavas* from the granite axial region, exposing their roots, in the form of dikes.

In conclusion, therefore, it seems best to make both the accumulation of the gravels and the lava flow which protected them, the dividing line between the Pliocene and the Quaternary, although I believe that glacial conditions had already commenced when these events occurred.

In a previous article already referred to, I have shown that the great lava flood commenced in its central part in Oregon, about the beginning of the Pliocene epoch, and has continued there almost to the present time. But as in volcanos the eruptions commence and perhaps continue in a central crater, and as erupted matters accumulate, later eruptions occur also on the outer margins; so in this great area of fissure eruptions, the eruptive activity commenced first in the center, but as erupted matters accumulated, the eruptive activity spread centrifugally to more and more distant points until at the end of the Pliocene it had reached Middle California.

Thus it seems to me that the four questions suggested by the phenomena of the old river beds and their fillings, have been not only each answered, but they have been all connected together in a satisfactory manner.

Sequence of Events.

It may be well to briefly recapitulate the main points of my view, by narrating rapidly the events in the order of their sequence.

Immediately after the birth of the Sierra Nevada, at the beginning of the Cretaceous period, a drainage system commenced to be formed. This system we may be assured remained unchanged during the whole Cretaceous and Tertiary times, for, as already seen, river channels are remarkable for their permanency. The result of the river-work of all this time was a system of broad trough-shaped channels separated by low divides usually called the Tertiary or old river system. During all this time I suppose the amount of detritus was so related to velocity that there was neither much erosion on the one hand, nor deposit on the other—though on the whole erosion slowly progressed. Then commenced the glacial cold at the end of the Pliocene, a rising of the Sierra region, and the

* Some Ancient Glaciers of the Sierra. This Journal, vol. v, p. 325, 1873, and vol. x, p. 126, 1875.

high Sierra was mantled with snow and ice and glaciers probably occupied the higher portions of the river troughs, and thus large quantities of loose debris were prepared ready for transportation. Then the ground heat of the impending lava flow melted the ice mantle and caused the rushing overloaded torrents which filled up the river channels. This filling doubtless required many years, perhaps centuries, during which there were alternate partial scourings out and re-fillings, yet the whole was, geologically speaking, a rapid process. Then immediately thereafter occurred the fissuring of the high Sierra, and immense discharges of ashes which, washed down by the still melting snows, formed mud streams, which almost completely filled up the river channels, and often apparently overran the low divides. Immediately following the ash-eruptions, lava streams flooded the mountain-slope and completely obliterated the drainage system. Coincidently with the eruptions, and as their cause, there was a considerable elevation of the Sierra range, and increase of the mountain slope.

The previous drainage having been abolished, glaciers and rivers immediately commenced cutting a new system wholly independent of the previous one, though having the same general direction. In cutting these new channels the rivers seem to have shown a preference for the old divides, because there the lava was either wanting or thinner than elsewhere. As a result of the increased elevation of the Sierra, as well as an increase of the causes which produced the Glacial epoch, the reign of ice now reached its culmination. At this time not only was the high Sierra ice mantled and all its cañons filled with glaciers, but even the much lower Coast Range was snow-capped, and glaciers probably ran down its valleys nearly or quite into the Bay of San Francisco.* As another result of the increased elevation of the Sierra and the prodigious consequent erosion by ice and water of this time, and of water alone in subsequent times, the erupted lava was swept clean away from the greater portion of the high Sierra, leaving only the roots visible in the form of dikes, and the river channels lower down the slope were cut far below the detritus-filled and lava-capped old river channels, which are thus left high up on the present divides. Meanwhile meteoric waters percolating downward through the decomposing lava caps, and therefore charged with carbonates of soda and lime, and therefore also dissolving silica, cemented the gravels and petrified the drift wood, or else taking more silica, changed in places volcanic and slate pebbles and bed rock into clay.

Berkeley, Cal., Oct. 15, 1879.

* I have found what I regard as good evidence of glacial action about the site of the University, 300 feet above the Bay of San Francisco.

ART. XXIV.—*Note on the Age of the Green Mountains;* by JAMES D. DANA.

HAVING in the new edition of my Geology, as in the preceding, referred the epoch of the formation of the Green Mountains, that is, of the folding, upturning and crystallization of its rocks, to the close of the Lower Silurian, I here present a fuller statement of my reasons for this conclusion. A further study of the stratigraphy of the eastern part of the region is required to establish its correctness beyond question; but I believe that the following facts and considerations will be found to be strongly in its favor.

By the term Green Mountains, I mean the swell of land with its ridges, about N. 16° E. in trend, which lies between the Connecticut River on one side, and Lake Champlain and Hudson River on the other, and reaching in the south to New York Island. All the rocks of the area thus bounded are not referable genetically to the range; for it is well known that the "Highland" region of Archæan rocks extends over the most of Putnam County, New York, and the southern border of Dutchess County; and that rocks of the same age constitute areas to the east of north of this Highland region, in Connecticut, and also farther north in Massachusetts and Vermont. These Archæan areas introduce difficulties into the geology of Western New England. But the Taconic range and the associated limestones are a known base in the study of the stratigraphy; and by working from it, the difficulties will quite surely be ultimately surmounted. For the sake of the present discussion, the Green Mountain region may be regarded as consisting of (1) a Western section, which includes the Taconic range or belt, and the associated bands of limestone, together with *conformable* formations of slate and schists; (2) a Central mountain section, separately distinguishable only in Vermont; and (3) an Eastern section. The mountain section in Vermont contains the highest summits of the Green Mountains, and is the part to which the name was given. In Massachusetts, the highest peaks are in the more western Taconic range; but still the greatest mean height lies south by west of the mountain belt of Vermont.

In the following pages, the evidence reviewed is arranged under the following heads:

(1) The extent to which the Western belt is a *known* region as regards geological age.

(2) The relations in rocks and stratification between the Western belt and those east of it.

(3) The occurrence of unconformable Upper Silurian rocks within the limits of the region or on its borders.

(4) The magnitude of *an individual* among mountains.

1. *The extent to which the Western belt is a known region as regards geological age.*—The facts on this point are presented in the writer's former papers,* and need not be here repeated. They establish (1) *by means of fossils*, the discoveries of Wing and others in Vermont, and of Dale, Dwight and the writer in Dutchess County, N. Y., and (2) *by the conformability of the strata*, the Lower Silurian age of the Taconic schists and of the associated limestones and schists, eastward to the easternmost of the limestone bands, and westward through Dutchess County, New York, to (and somewhat beyond) the Hudson River. Through their *conformability*, these strata show that all are one in system of dislocation and one in epoch of mountain-making; that the several Lower Silurian formations, from the Hudson River group to the Primordial, are involved in one system of conformable and simultaneously upturned beds.†

The width of this *known* region is, in the southern half of Vermont, 15 to 20 miles, or two-fifths of the width of the State; in Massachusetts, 15 to 20 miles: in Connecticut, 12 to 15 miles; in Dutchess County, N. Y., west of Connecticut, 23 to 25 miles, reckoning to the Hudson River.

The width for Western Connecticut and Dutchess County together is 35 miles, which is about half the whole width between the Hudson River and the Connecticut. North of Dutchess County, in Columbia and Rensselaer Counties, N. Y., the rocks are a continuation of the slates of Dutchess County, and are conformable to the Taconic, according to Mather and Emmons, and hence they belong to the same system. Consequently, the width through these counties and Western Massachusetts is 40 miles, or, again, half the distance from the Hudson to the Connecticut. The rocks are also Lower Silurian in Washington County, up to Whitehall, as represented in the geological maps of Hall and Logan; and in the northern half of Vermont, to its northern boundary.

It thus appears, that, of the mass of land which topographically belongs to the Green Mountain range, that part which is *already proved* to be Lower Silurian in age, and of one geo-

* This Journal, III. v, vi, 1873, xiii (Wing's discoveries), xiv, 1877, xvii, 1879.

† The conformability between the Taconic schists and the adjoining limestone I have observed at various localities in Vermont, Massachusetts, Connecticut and New York, part of the localities on the west side of the range and the rest on the east; and between the same limestone and the schists (including mica schists and gneiss) and quartzyte to the eastward also at several localities in Vermont, Massachusetts and Connecticut, so that the fact cannot rightly be questioned. The discoveries of fossils near Newburgh, *west* of the Hudson, by Whitfield and Dwight, are additional evidence as to the relation of the rocks.

logical and orological system constitutes nearly one-half of the whole range. The part of the Western belt which is not included in the above, is (exclusive of the Archæan area) the southern, or Westchester County, whose connection with the system has not yet been clearly made out.

I. Western Section of the Green Mountain Region.

2. *Rocks; Stratification.*—In mentioning the kinds of rocks we pass from north to south, and from west to east; the former direction follows the strike of the rocks and of the ridges, and the latter, transverse lines.

It is important to note, in reading the following, that hydromica schist and mica schist are essentially the same in composition, the former differing chemically from the latter only in the presence of a few per cent of water (not usually over 5). Physically the difference is wider; the hydromica schist being a fine-grained glossy slate (shading often into a variety that is *called* argillyte from its clay-slate aspect, and which is used as a roofing slate), and feeling more or less unctuous or talc-like.* This roofing slate from Fair Haven, near Castleton, Vermont, one of its most noted localities, is only a more finely grained hydromica schist; for in recent determinations of the alkalies made for the writer by Prof. O. D. Allen of the Sheffield Scientific School of Yale College, and by Mr. O. E. Atwater of the same School, the amount is as great as has been obtained for the hydromica schist, Prof. Allen finding potash 4·61 and soda 1·58 per cent, and Mr. Atwater, potash 4·62, and soda 1·64; and, moreover, the slate fuses rather easily to a light-colored slag. It is therefore a *hydromica argillyte*, or, better, *hydromica phyllyte.*

(1) In Vermont, unaltered and partially altered fossil-bearing Lower Silurian limestones, shales and sandstones occur along the western border of the State.

The Taconic range, next east, commences near Middlebury as a belt of roofing slate, the hydromica phyllyte just mentioned; but it becomes, to the southward, a belt of well characterized hydromica schist, yet with small beds of quartzyte in some places.

Next east of the main band of crystalline limestone (east of the meridian of Rutland), exists a second band of hydromica schist, which, in the southern half of the State, is formed largely of quartzyte; thick strata of quartzyte and hydromica schist alternate, and the former often graduates vertically and in the direction of the bedding into the latter by insensible shadings. Owing

* It is the so-called talcose schist and talcoid schist of the Vermont Report, which is shown in that Report (pp. 503-508, 522) to be non-magnesian. In this paper the terms of the Report are changed in all cases to hydromica schist.

to its greater hardness, high peaks consist of the quartzyte, and these have given the impression that this is the only constituent of the ridges—one not sustained either by the descriptions of Hitchcock in the Vermont Report, or by the writer's observations. The hydromica schist passes into chloritic, magnetitic and feldspathic varieties, and into a hydromica gneiss.*

(2) *South of Vermont.*

In New York, west of Massachusetts, occur slates like argyllite in aspect, but, largely, glossy slates which are hydromica schist; and the latter is the prevailing rock of Dutchess County, except toward its eastern border.

The rocks of the Taconic belt in Massachusetts are, besides ordinary hydromica schist, chloritic and garnetiferous varieties of it, and then in Connecticut, mica schist and staurolitic and garnetiferous schists; and farther south in Eastern New York, toward and below Pawling, 200 miles and more from the commencement of the band in Vermont, micaceous gneiss and gneiss. Again: The Vermont belt of hydromica schist and quartzyte, east of the main belt of limestone, continues through Massachusetts, with the quartzyte still a prominent feature. But the interstratifications, on going southward, are of quartzyte *with mica schist and true gneiss*, instead of with hydromica schist. The mica schists and gneiss are at first fine-grained varieties, but pass into coarser and well characterized kinds in Southern Massachusetts and in Connecticut.

The variation in the rocks on passing southward is very gradual; the extremes are 200 miles or more apart. In going eastward toward the central mountain belt, the same changes are passed through in an interval of 30 to 50 miles.

These different kinds of rocks in this western section are throughout in *conformable* strata, as already stated.

II. Eastern Section of the Green Mountain Region.

The following remarks are confined almost wholly to Vermont. Since the highest of the Green Mountain summits are in this State, we might here look for the strongest contrasts in the rocks on going eastward to the mountain section and beyond it, *unless all the three sections are of one mountain system.*

According to the geological map of Vermont and the descriptions in the Report by C. H. Hitchcock, a band of hy-

* C. H. Hitchcock describes well these gradations in the Vermont Report (pp. 507–509). He says "every grade from soft nacreous schist to sandstone may be found." In Cambridge, he says (p–524), there occur, besides hydromica schist, hydromica varieties of gneiss, sandstones and conglomerates, and plumbaginous and epidotic varieties of hydromica schist; also, all along the western part of Vermont (p. 529), and on the Connecticut River, it passes insensibly into clay slate. The writer observed similar facts in his study of the region.

dromica schist extends through the State on the east side of the mountain section, much like that on the west side; moreover, near the *northern* boundary of the State the two join and are one, showing thereby the closest relation between them. The eastern belt contains to the south some small beds of quartzyte and to the north as well as south, many localities of steatite and serpentine; and the western, while including much quartzyte, has to the north some small beds of steatite. The eastern becomes micaceous to the south and passes into mica schist; Mr. C. H. Hitchcock speaks in the Vermont Report (p. 510) of the gradual change to micaceous rocks, and accounts for it on the general principle that "the rocks grow more metamorphic as we proceed southward from the Canada line."

East of this eastern band of hydromica schist there is a band called clay slate, having parallel relations to that which exists in the western section (Taconic belt). Farther east, there are in the northern two-thirds of the State (besides some local granite areas), a north-and-south belt of mica schist ("Calciferous mica schist"), with some gneiss, and, beyond this, another of argillyte, with a small band of true hydromica schist in some parts near the Connecticut.

III. The Central Mountain Belt.

The mountain belt, which is only one to four miles wide in the northern three-fifths of the State, is marked gneiss on the geological map. But the descriptions in the text, and facts from other sources, show that for the northern fifty miles of its length the principal rock is not "Green Mountain gneiss;" that the most common kinds to the north are *hydromica schist* and *chloritic hydromica schist*.

In the far north, a few miles from the Canada boundary, stands Jay Peak, 4,018 feet in height above the sea level; it consists of hydromica schist much like that of the region adjoining on the east and west.* Thirty miles to the south there is Mt. Mansfield, 4,430 feet high (Guyot), the highest summit in the mountains; and it consists chiefly of mica schist, but in part is made of hydromica schist and chloritic hydromica schist,† and specimens of the latter gathered by the writer from the summit are not distinguishable from those of the true Taconic in Massachusetts. Fifty miles to the south is Camel's Hump, another of the high peaks, 4,088 feet high (Guyot), which consists, according to Adams, and observations by Mr. E. S. Dana, of mica schist; it is stated by Hitchcock

* Vermont Report, p. 523; Adams's Report, 1845. C. H. Hitchcock says (Rep. p. 600) of the Green Mountain gneiss "in Massachusetts, it was called mica schist because of the scarcity of feldspar in it. So here and in many parts of the Green Mountains, it might be appropriately called feldspathic mica schist."

† Vermont Report, 507-509.

to be gneissoid rock, meaning apparently gneissoid mica schist.*

It appears then, that even the mountain belt of Vermont in its northern half consists of rocks much like those of the region either side; and they are essentially the same for the rest of the belt, with this difference, that to the south the mica schist is replaced to a large extent by gneiss.

Again, according to the sections in the Vermont Geological Report and the text describing them, the *schists of the mountain belt are conformable* with the hydromica schist on the east and west.

In Massachusetts, the schists east of the limestone belt are mica schist (as in the Hoosac Mountain) and micaceous gneiss, and they are conformable, according to Hitchcock and my own imperfect observations, with the beds of the limestone belt. But an Archæan area extends northward from Connecticut, and, fifteen miles west of Pittsfield, interrupts the series. C. H. Hitchcock states in the Vermont Report (p. 462) that the mica schist of Hoosac Mountain is a continuation of the Green Mountain belt of gneiss, and that a diminution in the amount of feldspar makes the difference.

In Connecticut the rocks need more study before general conclusions can be positively stated, owing in part to the Archæan areas which give complexity to the subject in the northern half of the State.†

Connection between differences in the rocks and geographical distribution.—As has been shown, marked differences exist between the rocks of the north and south, and between those of the west and east; but the differences are so systematically distributed along the range that they are testimony to its essential unity. The differences are in the main just those that would have come for the most part, from differences in the grade of metamorphism. Intenser metamorphism should be naturally looked for along or about the axis of the range than to the west of it; and so, also (as shown by the facts connected with the Appalachians), on the eastern side of the axis than on the western; and thus it is in reality.

In view of such facts we may safely hold that if to the south, as in Westchester county, the rocks are mainly gneiss, this alone would not be sufficient evidence of difference of system or age.

* A letter from S. R. Hall and Z. Thompson, in Adams's Report (1845), says that there is no true gneiss east of a north and south line from Lake Memphremagog to the western line of Northfield.

† One fact may have much importance when the investigations are completed, namely: that on the west of New Haven, and therefore the west side of the Connecticut Valley depression, the rocks are, *first*, hydromica schist, which is in part almost argillyte in aspect, and in part chloritic, and is undistinguishable from that of the Taconic Mountains and of Mt. Mansfield; next a fine-grained garnetiferous mica schist; next, coarse gneiss and mica schist; and *all are strictly conformable*. The chloritic hydromica schist west of New Haven includes some metamorphic labradorite-dioryte, a rock I have not found in the Taconic region of Berkshire.

IV. Unconformability of Upper Silurian beds.

The three ranges of facts bearing on this point are the following:

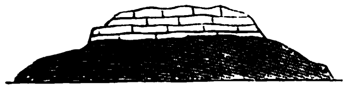
(1) The absence of Upper Silurian strata from among the conformable formations of the Green Mountains.

(2) The existence, near the *western* border of the mountain range, of fossiliferous Lower Helderberg limestone (upper divison of the Upper Silurian) resting *unconformably* on the upturned Hudson River slates.

(3) The existence of fossiliferous Lower Helderberg beds, and in some places Upper Helderberg, near the *eastern* border of the mountain range, in the Connecticut valley, resting *unconformably* on slates or schists which may be of Lower Silurian age, if not of the period of the Hudson River group.

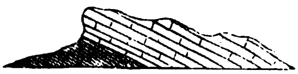
The cases of unconformability between the Lower Helderberg limestone and the Hudson River slates on the *western* side of the mountains occur in the Hudson River Valley, not far from the river, and are described and illustrated in Mather's New York Report (1843). The following figures are from his plates; they represent two cases east of the Hudson River

1.



Becraft's Mt., Columbia Co.

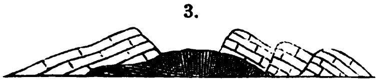
2.



Mount Bob, Columbia Co.

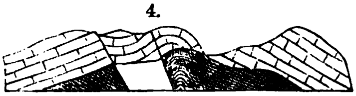
and four just west of it. Fig. 1. Becraft's Mountain, east of the city of Hudson (from Mather, plate 24), in which fossiliferous Lower Helderberg beds are nearly horizontal; fig. 2. Mt. Bob (from plate 38) a few miles south of Becraft's; fig. 3

3.



Between Glasco and the Great Falls of the Esopus, Ulster Co.

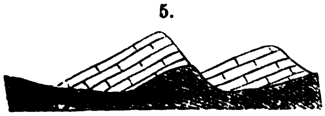
4.



Right bank of the Rondout, opposite Wilbur, Ulster Co.

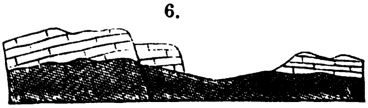
(from plate 7), in Ulster county, west of the river, between Glasco and the Great Falls of Esopus Creek; fig. 4 (from plate 26), in Ulster county, on the right bank of the Rondout; fig.

5.



Two miles northwest of Cocksackie, Greene County.

6.



Two or three miles west of Cocksackie, Greene County.

5 (from plate 8), in Greene county, two miles northwest of Cocksackie; fig. 6 (from plate 8), the same, two or three miles

west of Cocksackie. Mather describes another section on Pine Mountain, between Rondout and Kingston Point, where a high cliff of limestone overlies unconformably the gray grits of the Hudson slate series, the slates dipping 40° to 60° to the east-southeast, and the limestone 80° to the west-northwest. Other sections, from near Rondout, are given in the paper by Mr. T. Nelson Dale, in vol. xviii of this Journal (1879), p. 293.

Special descriptions of the localities are not here necessary. From the observed facts it was inferred by Logan that a very extensive formation of Lower Helderberg limestone once spread over the Hudson River valley; and it is certain that the beds were laid down, as he recognized, after the slates of the Hudson River region and other conformable rocks had been upturned; and since the slates are now proved to be of the Hudson River group, the making of a large part, if not the whole, of the Green Mountains preceded the era of the Lower Helderberg. The occurrence of Niagara limestone—the Coralline or Stromatopora limestone—at the Rondout locality (see the paper referred to by Mr. Dale, and Dr. Barrett's note in the same volume) is evidence, further, that the epoch of upturning or mountain-making preceded the Niagara period, which is the first of the Upper Silurian; and hence that it occupied the interval between the Lower and Upper Silurian.

The faulting and folding of the Upper Silurian strata prove the occurrence of later disturbances, which affected also the underlying unconformable slates; and these, as Mr. Dale suggests, may have taken place at the time of the Appalachian disturbance after the Carboniferous, and have been a consequence of the action which raised the Catskill Mountain plateau.

On the *eastern* side of the mountains the case of unconformable superposition of Upper Silurian fossiliferous rocks occurs at Bernardston, in northern Massachusetts, west of the Connecticut. The facts, first made known by Hitchcock, are given in detail in articles by the writer in this Journal.* The Lower Helderberg age of the fossiliferous beds and their unconformability to the underlying argillyte are admitted by all writers on the subject. These underlying slates are made conformable, in the Vermont Report, with the calcareous mica schist and these, as already stated, with the hydromica schist farther west, where the two are in contact. This point of conformability needs, however, further study before it is received as established. The underlying argillyte, although resembling that west of the mountain belt, is, therefore, not yet *proved* to be Lower Silurian. The reader can review the various considerations bearing on the question, and derive his own conclu-

* Third Series, vi, 339, 1873; and xiv, 379, 1877.

sion as to the probability in the case. The Crinoidal limestone at Bernardston is overlaid by quartzyte and fine grained mica schist which, since they cover a Lower Helderberg limestone stratum, may be metamorphic strata of the Oriskany group, or the lower beds of the Upper Helderberg. The similar beds of quartzyte and mica schist, with conformable beds of amphibolyte, staurolitic mica schist, and quartzytic gneiss and syenyte, representing the same formation, extend up the Connecticut valley. At Littleton, 120 miles to the north, east of the Connecticut River, occur beds of limestone containing fossil corals and Brachiopods of the Upper Helderberg; and on the northern borders of Vermont occur corals of the same age at Owl's Head, on the borders of Lake Memphremagog. These Lower and Upper Helderberg beds were made, as their positions and limits show, in an arm of the sea, which reached from the St. Lawrence region down what is now the Connecticut valley, and they seem to indicate, in connection with other facts, that the valley was defined at an epoch not long preceding the Lower Helderberg, or at that of the making of the Green Mountains.

V. The Magnitude of an Individual among Mountains.

A mountain-individual comprises all the elevations or results of upturnings and flexure that were produced over a continuous region in one mountain-making process; all that was made at one birth, or was monogenetic. Thus the mountain-individual called the Appalachian range comprises in its breadth not merely the various ridges and valleys that make the mountains west of the Blue Ridge, but the Cumberland Table Land and its extension northward to what was once a Catskill Table-land; and in its length it reaches from Central New York to Central Alabama. It has this great extent and yet it is one of the smallest of the earth's mountain individuals. Mountain individuals are necessarily large because they depend on movements in the earth's crust; and, if the crust were no more than twenty-five miles in thickness, deep bendings much less than 100 miles in span and some hundreds in length, would be, from a physical point of view, hardly a possibility. A very large area is therefore required for a mountain individual of folded rocks. It is hence natural, in the case of a mountain-individual along western New England, to look for a breadth at least equal to that of the region which the Green Mountains topographically cover. The Green Mountain region is a northern portion of the Appalachian system and these views make it simply a portion in which the mountain-making occurred at an earlier epoch, having been hastened, as

the writer long since suggested, by the existence on the west, near by, of the stable Archæan area of the Adirondacks.

In conclusion, I repeat the considerations that have been presented:

1. The *western* half of the region between the Connecticut River valley and the Hudson River, that is, the western half of the Green Mountain area, is proved to consist of rocks that are (1) of Lower Silurian age; and (2) of one orological system.

2. The schistose rocks of the eastern half, in Vermont are to a large extent similar to those of the western.

3. The rocks of the central mountain section in Vermont are, in its northern part, identical schists (hydromica, etc.), with those on the east and west sides of it.

4. The western border of the region in the Hudson River valley has itsfolded or upturned Hudson River (Lower Silurian) slates, overlaid unconformably by Niagara and Lower Helderberg (Upper Silurian) beds.

5. The eastern border of the region in the Connecticut valley at Bernardston, in Massachusetts, Vernon in Vermont, and the adjoining part of New Hampshire, has Lower Helderberg beds overlying, unconformably, folded or upturned roofing slates (similar to those on the western side), the Lower Silurian age of which is not improbable; and at Littleton in New Hampshire, and on Lake Memphremagog, in northern Vermont, occur unconformable Upper Helderberg (Lower Devonian) beds with fossils.

6. A mountain-individual of folded rocks is necessarily one of great magnitude.

In view of these various considerations, the evidence, although not yet beyond question, is manifestly strong for embracing the whole region between the Connecticut and the Hudson (and to an unascertained distance beyond) within the limits of the Green Mountain synclinorium.

Art. XXV.—*On a New Action of the Magnet on Electric Currents;**
by E. H. Hall, Fellow of the Johns Hopkins University.

Sometime during the last University year, while I was reading Maxwell's Electricity and Magnetism in connection with Professor Rowland's lectures, my attention was particularly attracted by the following passage in vol. ii, p. 144:

"It must be carefully remembered, that the mechanical force which urges a conductor carrying a current across the lines of magnetic force, acts, not on the electric current, but on the conductor which carries it. If the conductor be a rotating disk or

* From the American Journal of Mathematics, vol. ii., 1879.

id it will move in obedience to this force, and this motion or may not be accompanied with a change of position of electric current which it carries. But if the current itself ee to choose any path through a fixed solid conductor or a ork of wires, then, when a constant magnetic force is made t on the system, the path of the current through the conors is not permanently altered, but after certain transient omena, called induction currents, have subsided, the disition of the current will be found to be the same as if no netic force were in action. The only force which acts on ric currents is electromotive force, which must be distinhed from the mechanical force, which is the subject of this ter."

his statement seemed to me to be contrary to the most natuupposition in the case considered, taking into account the that a wire not bearing a current is in general not affected magnet and that a wire bearing a current is affected ex- in proportion to the strength of the current, while the size in general, the material of the wire are matters of indiffer-. Moreover in explaining the phenomena of statical electy it is customary to say that charged bodies are attracted rd each other or the contrary solely by the attraction or reion of the charges for each other.

oon after reading the above statement in Maxwell I read an le by Prof. Edlund, entitled "Unipolar Induction" (Phil. ., Oct., 1878, or Annales de Chemie et de Physique, Jan.,), in which the author evidently assumes that a magnet acts n a current in a fixed conductor just as it acts upon the luctor itself when free to move.

inding these two authorities at variance, I brought the stion to Prof. Rowland. He told me he doubted the truth Maxwell's statement and had some time before made a y experiment for the purpose of detecting, if possible, some on of the magnet on the current itself, though without suc-. Being very busy with other matters however, he had no ediate intention of carrying the investigation further.

now began to give the matter more attention and hit upon ethod that seemed to promise a solution of the problem. I my plan before Prof. Rowland and asked whether he had objection to my making the experiment. He approved of method in the main, though suggesting some very importchanges in the proposed form and arrangement of the apatus. The experiment proposed was suggested by the foling reflection :

f the current of electricity in a fixed conductor is itself atted by a magnet, the current should be drawn to one side he wire, and therefore the resistance experienced should be eased.

To test this theory, a flat spiral of German silver wire was inclosed between two thin disks of hard rubber and the whole placed between the poles of an electromagnet in such a position that the lines of magnetic force would pass through the spiral at right angles to the current of electricity.

The wire of the spiral was about ½ mm. in diameter, and the resistance of the spiral was about two ohms.

The magnet was worked by a battery of twenty Bunsen cells joined four in series and five abreast. The strength of the magnetic field in which the coil was placed was probably fifteen or twenty thousand times H, the horizontal intensity of the earth's magnetism.

Making the spiral one arm of a Wheatstone's bridge and using a low resistance Thomson galvanometer, so delicately adjusted as to betray a change of about one part in a million in the resistance of the spiral, I made from October 7th to October 11th inclusive, thirteen series of observations, each of forty readings. A reading was made with the magnet active in a certain direction, then a reading with the magnet inactive, then one with the magnet active in the direction opposite to the first, then with the magnet inactive, and so on till the series of forty readings was completed.

Some of the series seemed to show a slight increase of resistance due to the action of the magnet, some a slight decrease, the greatest change indicated by any complete series being a decrease of about one part in a hundred and fifty thousand. Nearly all the other series indicated a much smaller change, the average change shown by the thirteen series being a decrease of about one part in five millions.

Apparently, then, the magnet's action caused no change in the resistance of the coil.

But though conclusive, apparently, in respect to any change of resistance, the above experiments are not sufficient to prove that a magnet cannot affect an electric current. If electricity is assumed to be an incompressible fluid, as some suspect it to be, we may conceive that the current of electricity flowing in a wire cannot be forced into one side of the wire or made to flow in any but a symmetrical manner. The magnet may *tend* to deflect the current without being able to do so. It is evident, however, that in this case there would exist a state of stress in the conductor, the electricity pressing, as it were, toward one side of the wire. Reasoning thus, I thought it necessary, in order to make a thorough investigation of the matter, to test for a difference of potential between points on opposite sides of the conductor.

This could be done by repeating the experiment formerly made by Prof. Rowland, and which was the following:

A disk or strip of metal, forming part of an electric circuit,

was placed between the poles of an electro-magnet, the disk cutting across the lines of force. The two poles of a sensitive galvanometer were then placed in connection with different parts of the disk, through which an electric current was passing, until two nearly equipotential points were found. The magnet current was then turned on and the galvanometer was observed, in order to detect any indication of a change in the relative potential of the two poles.

Owing probably to the fact that the metal disk used had considerable thickness, the experiment at that time failed to give any positive result. Prof. Rowland now advised me, in repeating this experiment, to use gold leaf mounted on a plate of glass as my metal strip. I did so, and, experimenting as indicated above, succeeded on the 28th of October in obtaining, as the effect of the magnet's action, a decided deflection of the galvanometer needle.

This deflection was much too large to be attributed to the direct action of the magnet on the galvanometer needle, or to any similar cause. It was, moreover, a permanent deflection, and therefore not to be accounted for by induction.

The effect was reversed when the magnet was reversed. It was not reversed by transferring the poles of the galvanometer from one end of the strip to the other. In short, the phenomena observed were just such as we should expect to see if the electric current were pressed, but not moved, toward one side of the conductor.

In regard to the direction of this pressure or tendency as dependent on the direction of the current in the gold leaf and the direction of the lines of magnetic force, the following statement may be made:

If we regard an electric current as a single stream flowing from the positive to the negative pole, i. e., from the carbon pole of the battery through the circuit to the zinc pole, in this case the phenomena observed indicate that two *currents* parallel, and in the same direction, tend to repel each other.

If, on the other hand, we regard the electric current as a stream flowing from the negative to the positive pole, in this case the phenomena observed indicate that two *currents* parallel and in the same direction tend to attract each other.

It is of course perfectly well known that two *conductors*, bearing currents parallel and in the same direction, are drawn toward each other. Whether this fact, taken in connection with what has been said above, has any bearing upon the question of the absolute direction of the electric current, it is perhaps too early to decide.

In order to make some rough quantitative experiments, a new plate was prepared consisting of a strip of gold leaf about 2 cm. wide and 9 cm. long mounted on plate glass. Good con-

tact was insured by pressing firmly down on each end of the strip of gold leaf a thick piece of brass polished on the underside. To these pieces of brass the wires from a single Bunsen cell were soldered. The portion of the gold leaf strip not covered by the pieces of brass was about 5½ cm. in length and had a resistance of about 2 ohms. The poles of a high resistance Thomson galvanometer were placed in connection with points opposite each other on the edges of the strip of gold leaf midway between the pieces of brass. The glass plate bearing the gold leaf was fastened, as the first one had been, by a soft cement to the flat end of one pole of the magnet, the other pole of the magnet being brought to within about 6mm. of the strip of gold leaf.

The apparatus being arranged as above described, on the 12th of November a series of observations was made for the purpose of determining the variations of the observed effect with known variations of the magnetic force and the strength of current through the gold leaf.

The experiments were hastily and roughly made, but are sufficiently accurate, it is thought, to determine the law of variation above mentioned, as well as the order of magnitude of the current through the Thomson galvanometer compared with the current through the gold leaf and the intensity of the magnetic field.

The results obtained are as follows:

Current through gold leaf strip. C.	Strength of Magnetic field. M.	Current through Thomson galvanometer. c.	$\frac{C \times M}{c}$
·0616	11420 H	·00000000232	303000000000·
·0249	11240 "	·00000000085	329000000000·
·0389	11060 "	·00000000135	319000000000·
·0598	7670 "	·00000000147	312000000000·
·0595	5700 "	·00000000104	326000000000·

H is the horizontal intensity of the earth's magnetism $=\cdot 19$ approximately.

Though the greatest difference in the last column above amounts to about 8 per cent of the mean quotient, yet it seems safe to conclude that with a given form and arrangement of apparatus the action on the Thomson galvanometer is proportional to the product of the magnetic force by the current through the gold leaf. This is not the same as saying that the effect on the Thomson galvanometer is under all circumstances proportional to the current which is passing between the poles of the magnet. If a strip of copper of the same length and breadth as the gold leaf but ¼ mm. in thickness is substituted for the latter, the galvanometer fails to detect any current arising from the action of the magnet, except an induction

current at the moment of making or breaking the magnet circuit.

It has been stated above that in the experiments thus far tried the current apparently tends to move, without actually moving, toward the side of the conductor. I have in mind a form of apparatus which will, I think, allow the current to follow this tendency and move across the lines of magnetic force. If this experiment succeeds, one or two others immediately suggest themselves.

To make a more complete and accurate study of the phenomenon described in the preceding pages, availing myself of the advice and assistance of Prof. Rowland, will probably occupy me for some months to come.

Baltimore, Nov. 19th, 1879.

It is perhaps allowable to speak of the action of the magnet as setting up in the gold leaf strip a new electromotive force at right angles to the primary electromotive force.

This new electromotive force cannot, under ordinary conditions, manifest itself, the circuit in which it might work being incomplete. When the circuit is completed by means of the Thomson galvanometer, a current flows.

The actual current through this galvanometer depends of course upon the resistance of the galvanometer and its connections, as well as upon the distance between the two points of the gold leaf at which the ends of the wires from the galvanometer are applied. We cannot therefore take the ratio of C and c above as the ratio of the primary and transverse electromotive forces just mentioned.

If we represent by E′ the difference of potential of two points a centimeter apart on the transverse diameter of the strip of gold leaf, and by E the difference of potential of two points a centimeter apart on the longitudinal diameter of the same, a rough and hasty calculation for the experiments already made shows the ratio $\frac{E}{E'}$ to have varied from about 3,000 to about 6,500.

The transverse electromotive force E′ seems to be, under ordinary circumstances, proportional to Mv, where M is the intensity of the magnetic field and v is the velocity of the electricity in the gold leaf. Writing for v the equivalent expression $\frac{C}{s}$ where C is the primary current through a strip of the gold leaf 1 cm. wide, and s is the area of section of the same, we have $E' \propto \frac{MC}{s}$.

November 22d, 1879.

ART. XXVI.—*Measures of the Polar and Equatorial Diameters of Mars, made at Princeton, New Jersey, U. S.*; by Professor C. A. YOUNG.

THE polar compression of Mars has never yet been satisfactorily determined, the results of different observers ranging from that of Sir W. Herschel, who made it $\frac{1}{16}$, to that of Bessel, who found it insensible. The value $\frac{1}{62}$, deduced by Main at Oxford, from his measures in 1862–3, has probably been of late more generally accepted than any other, though by no means without reserve.

Hartwig, in his recently published investigation upon the diameters of Venus and Mars, gives $\frac{1}{96}$ as the result obtained by combining all the double-image measurements made at Königsberg, Leiden, Oxford, Berlin, Paris and Strassburg.

Either of these values, however, is apparently irreconcilable with the planet's known mass and period of rotation, if we admit the presence of water upon its surface, as the polar "snow caps" seem to indicate, except upon the almost absurd assumption of a density rapidly increasing from the center toward the surface.

It has seemed to the writer quite possible that the difference of illumination of the limbs of the planet, caused by phase, may lie at the bottom of the difficulty. Except on rare occasions there is phase enough, even at the moment of opposition, to produce a notable difference of appearance between the fully illuminated edge of the planet's disc and that opposite, a difference which can hardly fail to be felt in micrometric measurements. Unexceptionable observations for determining the polar compression can therefore be made only when the planet reaches opposition and its node together. This was so nearly the case last season, that on the night of November 12th, an observer on the planet would have witnessed a Transit of the Earth. At this time, and for a few days before and after, the phase was extremely small, and an opportunity was presented for determining the planet's ellipticity such as will not be available again for nearly half a century.

The measures detailed below were made by myself with a filar position micrometer attached to the nine and one-half inch Equatorial of the School of Science Observatory. The object glass of this instrument (by Clark) is constructed substantially upon the Gaussian curves, and is of the highest excellence. During the past year it has shown repeatedly both of the satellites of Mars, the two outer satellites of Uranus, and the Saturnian satellite Mimas, the last, for my eye, which is not extremely sensitive, being just at the limit of visibility. The teles-

cope doubles distinctly, and on fine nights easily, the little companion of α^2 Capriconi, nor has it yet failed upon any of the objects usually considered tests for twelve-inch instruments.

While perfectly aware that measures by a filar micrometer are subject to a considerable constant error, the measure of an illuminated disc being always excessive, I have thought they might safely be used in determining a difference of diameter in different directions. The wires were dark upon an illuminated field. The magnifying power throughout the observations was 398. The value of one revolution of the micrometer screw at 50° F., as determined by about a hundred star transits, is 17″·860±0·″003. The screw appears to be a very perfect one without sensible errors of periodicity or run.

Marth's ephemeris, in the Monthly Notices for June, 1879, was used in setting the position circle and in computing the minute phase-corrections. Each measure of a double diameter consisted of twenty settings of the micrometer wire, five with the movable wire on one side of the fixed wire, ten with it upon the other side, and finally five more in the first position. The correction for thickness of the wires was determined by a full set of readings at each of the three different fixed wires, once at least in each evening's work.

After each measurement of either diameter, the wires were turned 90° by the position circle, and the other diameter was measured. In some cases, however, after finishing a set of four measures (two of each diameter) at one of the fixed wires, the movable wire was transferred to another of the fixed wires, and the same diameter was then measured again as the first of a new set. The measures thus come in pairs, each measure of the polar diameter being matched with an equatorial immediately preceding or following. The only exceptions to the above statements are the asterisked measures of November 12th, which consisted of but *ten* settings each, and the polar diameter No. 23 (marked with a dagger) which has no strictly corresponding equatorial measure, work having been interrupted by clouds. A supplementary equatorial measure, No. 58, was therefore taken to equalize the numbers.

All the measures which were made are given, without omission or alteration of discordant readings. The weights assigned are on a scale of ten for a perfectly unexceptionable observation, and were determined from the atmospheric and other conditions at the time of observation. The total number of micrometer readings, exclusive of those for determining the thickness of wires, was 1140.

Had not cloudy weather prevented, the series would have been much more extensive. The nights of November 11th and 13th were entirely overcast; on November 12th only a

Equatorial Diameter of Mars, November, 1879.

No.	Date	Hour Angle	Angle with Vertic.	Measured Diam.	p	$\rho+\phi$ +	ω ±	I −	D_ω	pvv
	Nov.	h m	°	"					"	
2	7	−3 58	+74·5	20·824	9	+35	−200	−045	20·614	·0004
4	7	−2 00	+84·6	·814	9	+34	−200	16	·632	0
6	10	−3 45	+75·0	·702	6	10	− 83	44	·585	14
8	10	−3 03	+77·1	·887	8	10	− 84	37	·776	162
10	10	−0 47	−74·3	·779	8	10	− 83	46	·660	6
12	10	+0 02	−51·2	·878	5	12	− 84	106	·700	22
13	10	+0 54	−27·7	·954	6	14	− 84	149	·735	61
15	10	+1 31	−15·9	·722	6	16	− 83	162	·493	119
*17	12	−0 11	−57·9	·812	3	2	0	89	·725	25
19	14	−1 13	−83·4	·361	6	0	+133	19	·475	152
21	14	−0 25	−64·5	·415	7	1	+133	72	·477	165
24	15	−3 14	+76·7	·740	7	10	+219	39	·930	613
26	15	−2 32	+80·4	·683	5	9	+219	28	·883	310
29	15	−0 26	−64·9	·301	8	10	+215	71	·455	256
31	15	+0 03	−50·6	·289	8	12	+215	107	·409	225
32	15	+1 20	−18·5	·535	9	16	+217	159	·609	6
34	15	+1 55	−10·6	·960	4	17	+223	165	1·035	641
36	16	−3 52	+75·2	·063	3	17	+304	43	·341	257
38	16	−3 15	+76·8	·324	8	17	+309	38	·612	4
41	16	−0 54	−77·7	·660	8	16	+315	36	·955	824
43	16	−0 22	−62·9	·869	4	17	+318	77	1·127	972
44	16	+0 15	−44·8	·285	7	20	+309	119	·495	135
46	16	+0 41	−33·0	·084	6	21	+306	141	·270	795
49	16	+1 53	−11·1	·555	8	24	+313	165	·727	69
51	16	+2 18	− 6·8	·426	9	25	+310	167	·594	14
52	16	+2 29	− 5·3	·615	7	25	+313	167	·786	162
55	17	−3 38	+75·7	·051	4	25	+396	41	·431	165
56	17	−3 23	+76·3	·159	7	25	+398	40	·542	60
†58	17	−2 52	+78·6	20·066	6	24	+396	− 33	·453	197

Equatorial Diameter, 20"·634 ± 0·035. $a = \mathrm{Io} = 0''\!\cdot\!168 \pm 0''\!\cdot\!050$.

single pair of measures of small weight could be obtained, and on the 14th only two pairs and an odd one. On all the other nights there were also occasional periods of atmospheric disturbance or entire interruptions. It is especially to be regretted that more measures were not obtained at considerable western hour angles, as they would have gone far to eliminate the effects of atmospheric dispersion and astigmatism of the observer's eye. The observations have been very carefully reduced under my direction, by my assistant, Mr. M. McNeil, who deserves and has my warmest thanks for his interest and help in the matter.

In the accompanying tables the first column contains the reference number of the observation; the second gives the date, the third the hour angle of the planet, and the fourth the angle between the measured diameter and the vertical. The fifth column contains the measured diameter, corrected for thickness of wires and reduced to arc, and the sixth, headed p, gives the assigned weight. The seventh column, $(\rho+\varphi)$, contains the sum of the corrections for refraction and phase in

***Polar Diameter of Mars, November*, 1879.**

No.	Date	Hour Angle	Angle with Vertic.	Measured Diam.	p	$\rho+\phi$ +	ω ±	I −	D_ω	pvv
	Nov.	h m	°	"					"	
1	7	−4 08	−16·0	20·801	9	+24	−200	−161	20·464	0·0070
3	7	−2 20	− 8·8	·684	9	15	−199	−166	·334	427
5	10	−4 08	−15·4	1·066	4	19	− 83	162	·840	332
7	10	−3 24	−14·0	·906	6	14	− 84	165	·671	88
9	10	−1 12	+ 6·6	·793	8	8	− 84	167	·550	0
11	10	−0 23	+26·3	·810	8	6	− 82	151	·583	8
14	10	+1 11	+68·3	·805	8	2	− 83	62	·662	97
16	10	+1 53	+78·9	·585	7	1	− 82	32	·472	45
*18	12	0 00	+37·7	1·041	3	0	0	133	·908	380
20	14	−0 56	+12·4	·359	7	7	+133	164	·335	330
22	14	−0 10	+32·6	·351	7	5	+133	142	·347	294
†23	14	+1 33	+74 5	·459	7	1	+133	45	·548	0
25	15	−2 51	−11·0	·932	4	11	+222	166	·999	799
27	15	−2 14	− 7·2	·819	4	10	+220	167	·882	436
28	15	−0 42	+18·0	·247	7	7	+214	160	·308	416
30	15	−0 10	+32·8	·272	7	7	+215	141	·353	277
33	15	+1 39	+75·9	·680	7	2	+219	41	·860	664
35	15	+2 11	+82·1	·286	5	1	+215	23	·479	26
37	16	−3 32	−14·1	·497	5	17	+312	163	·663	62
39	16	−2 57	−12·0	·452	9	15	+312	164	·615	36
40	16	−1 06	+ 9·0	·620	5	11	+313	166	·778	255
42	16	−0 41	+18·6	·702	4	11	+314	159	·868	400
45	16	+0 29	+51·8	·417	9	7	+310	104	·630	55
47	16	+0 54	+62·2	·336	9	6	+309	78	·573	4
48	16	+1 40	+76·2	·058	6	5	+306	40	·329	298
50	16	+2 06	+81·3	·181	7	4	+307	25	·467	50
53	16	+2 47	+86·6	·172	7	4	+307	10	·473	43
54	17	−3 54	−14·9	·268	8	22	+400	162	·528	5
57	17	−3 12	−13 0	20·100	7	18	+398	−164	·352	280

Polar Diameter, 20"·552 ± 0"·043. C = 0"·082 ± 0·035. Polar compression = $\frac{1}{219}$.

units of the third decimal; the eighth column (ω) gives the reduction to opposition, or the correction necessary to reduce the observed diameter to what it would have been if the planet were at the same distance from the earth as at the instant of opposition. The next column, headed I, contains a correction, which will be explained below, depending upon the inclination of the measured diameter to the vertical; the column $D\omega$ contains the concluded opposition-diameter, and the last column, the product obtained by multiplying the square of each residual by the weight. For the polar diameter $\Sigma pv^2 = 0·6177$, for the equatorial, 0·6435: both together = 1·2612.

If we apply the corrections for refraction, phase, and reduction to opposition, and group the results according to the angle made by the observed diameter with the vertical, it at once becomes evident that a further correction is needed, horizontal lines being systematically measured smaller than the same when vertical. Thus, if we take the twenty measures of the equatorial diameter made when its inclination to the vertical was more

than 45°, we get for the mean (by weights) $20''.687 \pm 0''.028$ at a mean angle of $72°.4$. The nine nearly vertical measures, give $20''.780 \pm 0''.044$ at a mean angle of $19°.3$. Similarly the ten nearly horizontal measures of the Polar diameter give $20''.608 \pm 0''.031$ at a mean angle of $73°.8$, while the nineteen nearly vertical measures give $20''.706 \pm 0.926$, at a mean angle of $16.°9$. No sensible difference appears between results obtained when the measured diameter inclines to the right, and those obtained when the inclination is toward the left.

It is not certain what causes produce this difference between horizontal and vertical measures, but it is probably due in part to atmospheric dispersion, and partly to a known vertical astigmatism of the observer's eye. In either case the effect would be proportional to the cosine of the inclination, and we may therefore assume with sufficient approximation, that the correction required to an observation is $I = a \times \cos \beta$; β being the angle with the vertical, and a a constant to be determined from the observations themselves.

Approximate values of a can be obtained from the data given above; thus from the two groups of equatorial measures, (regarding each group as a single measure) we get $a = 0''.149$. The two polar groups give $a = 0''.146$; a coincidence which strongly attests the reality of the correction.

It is not, however, strictly correct to treat these groups as single observations. The more legitimate course is to regard each observation, (corrected for refraction and phase and reduced to opposition) as furnishing an equation of condition of the form

$$\textit{measured diameter} = \textit{true diameter} + a \cos \beta.$$

This has been done, and from the equations of condition, using the weights given, normals have been formed, in several different ways.

Thus we may take as the unknown quantities π, ϵ, (the polar and equatorial diameters) and a. Or calling $c = \epsilon - \pi$, we may take as the unknowns a, π and c, or a, ϵ and c. Or finally, putting $m = \frac{\epsilon + \pi}{2}$, we may form our normals with m, c and a. Whichever of the four sets of normals we use, we get for the unknown quantities involved, the following values, weights and probable errors, viz:

ϵ (Equatorial Diam., Nov. 12, 1879)	$= 20''.634 \pm 0''.034$	;	wt. 8·92
π (Polar Diam., " " ")	$= 20.552 \pm 0.043$	;	wt. 5·85
$m = \frac{\epsilon + \pi}{2}$	$= 20.593 \pm 0.035$	;	wt. 8·85
$c, = (\epsilon - \pi)$	$= 0.0818 \pm 0.0348$	;	wt. 8·75
a coefficient of inclination correction	$= 0.168 \pm 0.050$	;	wt. 4·17

The introduction of the correction I reduces the sum of pv^2 from 1·3994 to 1·2612.

The values of the diameters are of course not very reliable, being subject to the considerable constant error which always affects filar micrometer measures. If we accept Hartwig's determination, 9″·352,* for the diameter at distance unity, a value which depends upon the whole body of heliometer and double-image micrometer measures up to 1877, we get for the opposition diameter of 1879, 19″·128. Comparing this with my mean, we find 1″·46 as the constant error of my filar micrometer measures, a value rather unexpectedly large, but not unprecedented.

This constant error can however have but very slight, if any, influence upon the measured difference of diameters, and we find for the ellipticity of the visible periphery of the planet, the value $\frac{0''\cdot0818}{19\cdot128}=\frac{1}{234}$.

As the pole was not on the periphery, but according to Marth's ephemeris at a distance of 14°·5 from it, a slight correction is still needed to deduce the true polar compression. The diameter measured as polar was that joining two antipodal points in Areographic latitude 75°·5. Recalling the formula for the radius of a spheroid at any latitude, viz:

$$\rho = a\sqrt{\frac{1-2\,\varepsilon^2\sin^2\varphi+\varepsilon^4\sin^2\varphi}{1-\varepsilon^2\sin^2\varphi}},$$

and putting $\frac{\rho}{a}=\frac{233}{234}$ we easily find ε, the eccentricity of a planetary meridian, and from it C_0, the polar compression. Performing the solution we get $C_0=\frac{1}{219}$, which may be taken as the final result of the work here detailed.

The limits of probable error extend from $\frac{1}{156}$ to $\frac{1}{364}$, and so far as can be judged from the observations themselves, the chances are more than two to one that the ellipticity lies between $\frac{1}{139}$ and $\frac{1}{516}$.

The work of reduction was nearly finished before the writer had seen Professor Adams's recent paper upon the orbits of the satellites of Mars, in which he gives $\frac{1}{228}$ as the ellipticity which the planet ought to have if it follows the same law of central density as the earth. The closeness of the accordance is probably in considerable degree accidental, but it is quite satisfactory.

Princeton, New Jersey, Jan., 1880.

* The mean diameter 20″·593 resulting from my observations, when reduced to distance unity, gives 10″·068; a value sensibly identical with that obtained by Peirce from a discussion of the Washington Mural circle observations, and used in the American Ephemeris.

ART. XXVII.—*On the Use of the Sine-formula for the diurnal Variation of Temperature;* by B. A. GOULD.

IN the "Jahresbericht des physikalischen Centralobservatoriums für 1877 und 1878," Dr. H. Wild, the eminent director of that institution, has recently published some deservedly severe remarks upon the large amount of time and labor which is unprofitably spent in making observations with inaccurate instruments, and calculations with inaccurate or insufficient data. Probably there is no physicist who has occupied himself with meteorological studies to any extent without finding his attention forcibly attracted to the same considerations; and it would be needless to add any testimony in support of the general tendency of Dr. Wild's remarks.

But to my surprise I find a foot-note appended to them, which I transcribe in the original, lest I do it injustice in the attempt to translate:

"Ich kannte damals noch nicht den eben erst erschienenen Band mit den physikalischen Beobachtungen der amerikanischen Expedition der "Polaris," wo Herr E. Bessels das Abschreckendste in ganz unnützen Berechnungen aller meteorologischen Elemente nach der Bessel'schen Formel geleistet hat. Schade um die Zeit, die so für eine bessere Verwerthung der schönen Beobachtungen verloren ging. Die Palme der Leistungen in dieser Richtung gebührt freilich Hrn. Gould, der es in dem erst erschienenen, im übrigen sehr werthvollen ersten Bande der 'Anales de la Oficina Meteorólogica Argentina' zu Stande gebracht hat, für Buenos Aires, aus bloss 3 Beobachtungen am Tage, 4 Constante der Bessel'schen Formel zu bestimmen, und damit den täglichen Gang der Temperatur, des Barometerstandes, der Bewölkung, etc. zu berechnen."

Had this criticism emanated from any one whose scientific position and services in meteorology were less distinguished, or whose opinions seemed entitled to less deference than is deservedly conceded to those of Dr. Wild, I should not reply to it. But, under the circumstances, I ask leave to call attention to one or two considerations which he has overlooked in the sarcastic intimation that I had undertaken to determine four unknown quantities from three equations.

As answer, I might, it is true, cite the facts; since the series of observations made for many years at 8 A. M., 2 P. M. and 8 P. M.,—a part of which is printed on pages 314 to 359 of the volume referred to,—were incorporated in the computations as well as the series made at 7 A. M., 2 P. M. and 9 P. M. One hour being common to both systems, it was easy to determine the small constant correction needed for making the two sys-

tems congruous. And it will be seen that in determining the diurnal variation of the temperature (pp. 412–414) and its expression by the goniometric formula, five daily observations were really employed instead of three only as stated by Dr. Wild.

It is, however, not this circumstance which leads me to make a public rejoinder; but the general principle involved. For as regards the diurnal *barometric* variation, the constants of the sine-formula have in truth been deduced from the results of only three daily observations. By reference to page 427, it will be seen that I intentionally disregarded the results of the two others on account of their apparent want of congruity with the other series made by a different observer and with a different instrument. Here Dr. Wild's implied censure might find application from his point of view; and it is with reference to this that I desire to reply.

There are, in these cases, conditions attendant upon the problem which serve the purpose of additional equations. Even were the so-called formula of Bessel to be regarded solely as a means of interpolation, as Dr. Wild seems to suppose it, the conditions that the daily maximum of temperature occurs within two or three hours after noon, and the minimum not very long before sunrise, furnish the requisites for deducing four constants from observations made at proper intervals three times a day. In determining the diurnal variation of the barometer, the attention of the reader is, on page 427, directed to this circumstance, and the two hypotheses are distinctly stated upon which the values of the constants depend. It appears to me that any just criticism of the investigation must rather be directed against the propriety of these hypotheses, than against the legitimateness of the method.

There is yet another consideration which, although not fully set forth in the printed volume, has guided me in the course which I have pursued, and in which I purpose to continue, in the investigation of the climatic constants for other points in South America. It is that observations made at other hours and not very remote places accord in confirming the general form of the diurnal curves, which is the only hypothetical assumption. The observations made before the "Oficina Meteorológicæ" was established, but especially the series which have for some years been carried on at this observatory, afford such corroboration. The monthly means of the hourly observations made here during the last two years are very well represented by the sine-formula with only three variable terms. The object of the investigations is to attain a knowledge of the true laws. If there really are laws, they must be capable of expression by some algebraic formula; and numerous tests

have shown that the sine-formula affords such expression more conveniently than any other known to me; so that the well-established general form of the diurnal curves in these regions affords the only requisite in addition to the three daily observations for a trustworthy determination of the constants. The only possible objections to this procedure are: either that the diurnal curve is in fact not a true curve, or that the assumptions relative to its form are too uncertain to take the place of an equation of condition. That, in these regions at least, both of these objections would be untenable it would be extremely easy to prove.

In his treatise upon the Temperatures of the Russian Empire, published in the Supplementary volume of the "Repertorium für Meteorologie," Dr. Wild has taken the positions—1st, that the sine-formula represents no law whatever in the diurnal variation, but is solely a means of interpolation; and 2d, that the mean daily changes of temperature cannot be expressed by any simple curve. And he gives practical expression to these opinions by totally abandoning the employment of all general formulas, even for those places where the observations are made hourly. It is apparently in advocacy of this singular doctrine that he has made the scarcely courteous comments which prompt the present remarks.

Even were the formula in question solely one of interpolation, I cannot see how in this respect the eye and free hand of a draughtsman could be more correct. Yet it would seem that Dr. Wild intends to assert this, and that he believes that the moments of mean daily maximum and minimum can be better determined by graphical approximation than by numerical determination.

Far be it from me to object to graphical methods. There is no doubt of the fact that in various investigations for which much more nicety is requisite than is attainable in determining atmospheric temperatures, such methods are most serviceable. But, so far as my knowledge extends, it has never before been asserted that they afford greater accuracy than numerical ones. And, putting this question aside, how can the excessive minuteness with which the temperatures at given moments of local time at the various stations have been referred to moments of Göttingen time, by reductions calculated to hundredths of a degree, be supposed to afford a corresponding accuracy, unless there be reason to suppose that the observations were in general really made at the instants recorded,—that the clock even was always sharply determined, the observers unfailingly punctual, and at least the observed tenths of degrees reasonably trustworthy. (See "Supplement Band," p. 36.) In such cases we cannot even suppose a compensation in the errors of obser-

Differences (O.–C.) *between the mean hourly temperatures observed at Cordoba and those corresponding to Bessel's formula for the daily variation.*

	1877. Dec.	1878. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1879. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Mean
0h	+0°·04	−0°·15	−0°·03	−0°·15	+0°·13	+0°·02	+0°·16	+0°·21	+0°·06	0°·00	+0°·17	−0°·14	−0°·15	+0°·01	+0°·02	+0°·18	+0°·10	+0°·17	+0°·23	+0°·31	−0°·01	+0°·11	−0°·03	+0°·06
1 AM	−0·16	+0·14	+0·27	+0·18	+0·53	+0·09	+0·25	+0·08	+0·14	−0·11	−0·30	+0·04	−0·20	−0·31	−0·13	+0·07	−0·03	+0·21	+0·17	+0·29	−0·01	+0·03	+0·13	+0·06
2	−0·05	−0·16	+0·04	+0·17	−0·05	−0·14	−0·26	−0·09	−0·24	−0·35	−0·34	+0·14	−0·04	−0·09	−0·19	−0·20	−0·29	−0·06	−0·03	−0·18	−0·04	−0·23	+0·55	−0·09
3	+0·34	+0·03	−0·08	−0·21	−0·36	−0·15	−0·10	−0·22	−0·10	−0·05	+0·35	+0·07	+0·35	+0·09	+0·06	−0·17	−0·25	−0·16	−0·13	−0·39	+0·12	+0·01	+0·68	−0·01
4	+0·14	+0·01	−0·02	−0·07	0·00	+0·16	+0·20	+0·23	+0·08	+0·12	+0·37	+0·20	+0·12	+0·32	+0·23	+0·32	−0·06	−0·13	−0·02	+0·23	−0·25	+0·22	+0·23	+0·11
5	−0·12	0·00	+0·28	+0·22	+0·26	+0·05	−0·01	+0·01	+0·13	+0·45	+0·07	−0·12	−0·35	−0·01	+0·08	+0·14	+0·11	+0·23	−0·05	+0·14	+0·17	+0·04	−0·62	+0·08
6	+0·17	+0·14	0·00	−0·06	+0·45	+0·45	−0·01	+0·21	−0·11	+0·10	−0·80	−0·36	0·00	−0·50	−0·33	−0·21	+0·04	+0·14	+0·34	+0·20	+0·11	−0·16	−0·95	−0·08
7	+0·27	−0·07	−0·20	−0·09	−0·53	−0·54	−0·07	−0·05	−0·28	−0·40	−0·03	+0·13	−0·12	−0·01	−0·35	−0·48	−0·21	−0·35	−0·26	−0·24	−0·22	−0·34	−0·44	−0·21
8	+0·22	−0·20	+0·01	+0·12	−0·05	−0·25	−0·13	−0·27	+0·13	+0·56	+0·61	+0·37	+0·52	+0·38	+0·39	+0·41	+0·09	−0·04	−0·16	−0·29	+0·01	+0·50	+0·40	+0·14
9	+0·14	+0·22	+0·08	−0·03	+0·25	+0·08	+0·32	+0·21	+0·17	+0·34	+0·29	+0·30	−0·26	+0·24	+0·31	+0·42	−0·09	+0·19	+0·29	+0·31	+0·22	−0·08	+0·49	+0·19
10	−0·11	−0·02	+0·02	+0·05	+0·03	+0·26	−0·13	+0·31	−0·06	−0·35	−0·47	−0·59	−0·12	−0·37	−0·28	−0·41	−0·33	+0·04	0·00	+0·20	−0·22	+0·03	+0·36	−0·09
11	+0·11	+0·15	−0·32	−0·12	−0·14	−0·03	−0·23	−0·04	−0·02	−0·34	−0·30	−0·04	−0·03	−0·38	−0·43	−0·25	−0·24	−0·13	−0·27	−0·38	−0·03	−0·40	+0·38	−0·18
12M.	+0·07	−0·25	+0·02	+0·07	−0·36	−0·01	+0·41	−0·46	−0·19	+0·09	+0·12	+0·17	+0·08	+0·51	+0·26	+0·21	+0·26	+0·01	+0·10	+0·17	+0·27	+0·19	−0·06	+0·07
1 PM	+0·11	−0·02	−0·18	−0·07	−0·18	+0·18	−0·18	+0·39	+0·15	−0·27	+0·22	−0·07	+0·05	+0·07	+0·24	+0·20	0·00	+0·05	+0·30	+0·01	−0·33	+0·14	−0·38	+0·02
2	−0·09	+0·21	+0·20	+0·15	+0·12	0·00	+0·12	+0·16	+0·34	+0·24	+0·28	+0·25	−0·04	−0·02	+0·07	−0·07	+0·14	+0·04	−0·28	0·00	+0·31	+0·03	−0·49	+0·07
3	−0·12	+0·02	−0·32	−0·04	−0·05	−0·08	−0·29	−0·42	−0·33	−0·39	−0·43	−0·05	+0·20	−0·24	−0·24	−0·04	+0·19	−0·10	−0·07	−0·21	−0·19	−0·18	−0·34	−0·10
4	−0·35	−0·18	+0·02	−0·09	+0·07	−0·25	+0·30	+0·15	+0·07	+0·05	−0·02	−0·34	−0·25	+0·13	−0·08	−0·23	+0·16	+0·12	+0·15	+0·12	+0·05	−0·07	−0·05	−0·09
5	+0·31	+0·13	+0·19	+0·20	+0·04	−0·02	−0·01	−0·07	+0·23	+0·29	+0·12	+0·02	−0·07	−0·02	+0·09	+0·19	+0·07	+0·03	0·00	+0·09	+0·11	+0·12	+0·37	+0·10
6	−0·45	−0·27	−0·48	−0·38	−0·43	−0·13	−0·20	−0·10	−0·12	+0·06	+0·13	+0·18	+0·09	−0·07	+0·18	+0·09	−0·26	−0·09	+0·13	−0·04	−0·17	+0·12	+0·71	−0·07
7	−0·09	+0·34	+0·30	+0·18	+0·29	+0·08	−0·11	+0·10	+0·03	+0·06	−0·14	−0·08	+0·13	+0·36	+0·18	−0·13	+0·09	−0·10	−0·29	−0·17	+0·03	−0·13	+0·45	+0·06
8	0·00	0·00	+0·18	+0·14	+0·03	+0·31	+0·29	−0·25	−0·02	+0·32	+0·14	−0·16	+0·02	−0·27	−0·24	−0·06	+0·16	+0·23	−0·05	−0·14	+0·10	+0·03	−0·19	+0·02
9	−0·28	−0·20	−0·30	−0·11	+0·08	+0·30	−0·05	+0·19	+0·10	−0·21	−0·28	+0·09	−0·25	−0·27	−0·18	+0·09	+0·16	+0·01	+0·39	+0·56	−0·02	+0·03	−0·44	−0·02
10	−0·10	−0·01	+0·31	+0·19	−0·11	−0·20	−0·07	−0·12	−0·18	+0·03	+0·11	+0·16	+0·10	+0·19	+0·23	+0·03	+0·18	−0·01	+0·01	−0·23	−0·04	−0·07	−0·42	−0·06
11	0·00	+0·14	+0·01	−0·25	−0·02	−0·18	−0·20	−0·16	+0·02	−0·23	+0·13	−0·17	+0·22	+0·23	+0·11	−0·10	+0·01	−0·30	−0·50	−0·36	+0·03	+0·06	−0·34	−0·08
$\sqrt{\Sigma v^2}$	0·19	0·16	0·20	0·16	0·25	0·22	0·20	0·22	0·16	0·27	0·31	0·22	0·19	0·26	0·23	0·22	0·18	0·15	0·22	0·25	0·17	0·18	0·43	0·09
Ampl.	10·8	10·6	10·5	7·9	9·7	12·3	9·8	14·2	12·4	13·4	13·7	12·5	13·6	14·8	11·7	9·5	10·7	12·3	13·2	11·1	12·3	14·7	10·5	

vation, inasmuch as the effect of a given error in the time differs at different seasons. Yet, in spite of all this, these insignificant minutiæ seem to be thought worthy of application to data obtained by the free hand of a draughtsman, rounding off errors in the observations, while the representation and generalization of the results by a formula accompanied by an exact exhibit of its discordances from the several observations, is deemed inadmissible.

If the epochs of daily minimum, as deduced from monthly means of hourly observations by the two methods, differ (as at Katharinenburg, for example) by amounts varying between +57 and −71 *minutes*, I cannot agree with the distinguished author in attributing a large share of such discordances to errors occasioned by the use of Bessel's formula; nor even in preferring the results of the graphical method. It seems much more probable that the phenomenon ought to be attributed to a very different class of influences. It is at least certain that what the draughtsman obtains without gauge or measure in equating out a series of data, the formulas will afford together with accurate indications of the probable errors. Yet if in the numerical computations the manifest uncertainties and contradictions of inaccurate data may not be equated out, while on the other hand, the draughtsman's line may be boldly drawn across and through all such irregularities, it is highly probable that this latter method may furnish a line which represents the true law with a nearer approximation. When not too many terms are employed, the general formula gives correctly what the graphical process only gives approximately; and by a glance at the residuals the computer sees what additional degree of accordance with the data may be attained by the introduction of an additional term. Finally, upon the hazardous assumption that all the data are faultless, so that only an accurate interpolation is needed, any number of observations may be represented with absolute precision by the formula. Yet recourse to a computation in which twelve variable terms are used to represent twenty-four hourly observations is very nearly equivalent to a declaration that the computer believes no periodic law to exist.

That entirely similar discordances present themselves between the times of maxima and minima, as obtained by the two methods, for other stations than the one cited can cause no surprise. The only surprising fact in the case is that the inference should have been drawn that the employment of a cyclical formula is inadmissible even when it represents the entire series of observations within the limits of reasonable error.

Still retaining the hypothesis already mentioned regarding the character of the service rendered by the sine-formula, a

great advantage must certainly be derivable from a general expression which absolutely represents such observations as exist, even though it might not be demonstrably correct for intermediate moments. Objections may be urged against the abuse or improper application of such a formula, but there is certainly a legitimate use for it. An empirical periodic function can be made to represent any number of observations of any periodic fluctuation, provided the number of constants be equal to that of the independent data. Whether it does or does not, at the same time represent the true law throughout its extent is a separate question. But surely the attainment of a general expression which represents the available observations is most important, since the higher terms serve to make manifest the degree of confidence to which the lower ones are entitled.

If, however, with an inferior number of constants, a satisfactory representation can be obtained, we have an argument to a corresponding extent, that the periodic variation does in fact follow the law expressed by the formula. This ceases to be simply an implement of interpolation, whenever the number of its constant is less than is logically required by the data and the conditions which it adequately satisfies. Consequently if the coëfficient of the third term is small in a formula which well represents a given number of observations, we have thus a measure of the trustworthiness of the preceding terms, and at the same time are informed what epicyclical term suffices to satisfy the existing series. But when a large number of successive observations, in all parts of the cycle can be sufficiently well represented by a small number of terms, this fact gives evidence that the true law is expressed by the formula. This is the only basis for a legitimate application of Bessel's formula to the diurnal variation of temperature. If it represents the true law, it ought to be used, since it affords the most general and convenient expression.

The monthly means of the hourly observations of temperature at Cordoba have been found capable of representation with great accuracy by sine-formulas with only three variable terms. The average mean discordance for a single hour, since November, 1877, is 0·28° or scarcely greater than the error to be apprehended in a single observation, when all sources of error are considered. For the barometer this discordance is less than 0·05°. We have thus the evidence that the formula represents the true law of nature with close approximation; and the degree of approximation is furthermore attested by the character of the residuals, irrespective of their magnitude. If the mental constitution of the investigator is such that he prefers to have a definite numerical expression for the degree of approximation, he may find this in the subsequent terms. I consider it

fully justifiable to employ a similar formula for discussing a small number of daily observations made at places not too remote and in which the topographical conditions are not too different. The results so obtained thus far fully confirm this view, and especially those relative to the variations of temperature.

In his treatise on the temperature of the Russian Empire, Dr. Wild arrives at a conclusion which he expresses as follows (p. 95): "For interpolating omitted hours, especially those of the night, the formula of Lambert and Bessel can,—according to Theorem 11 regarding the form of the curve of the diurnal period in the temperature,—only be applied, at most, for entirely maritime climates. For all places of which the situation is in any degree continental, it must be totally rejected, on account of the sudden bend in the curve at the time of sunrise, which it is only capable of representing by the employment of very many terms (10 or more), even for complete series of hourly observations."

That this conclusion does not hold good for Cordoba will, I think, be manifest to any one upon inspection of the preceding table, which exhibits the residuals between the monthly means of hourly observations and the corresponding values afforded by the monthly sine-formulas with four variable terms. Cordoba is situated about 400 miles from the La Plata in a straight line, and about 620 from the Atlantic, its position being preëminently continental. Buenos Aires, however, for which point my use of the sine-formula is so sharply censured by Dr. Wild, is a seaport.

The residuals which result from the use of only three variable terms are by no means important, though of course somewhat larger than those given in the table. There is a certain tendency to grouping of their signs by triplets which shows that the fourth term may be added with advantage ; yet neither their order of magnitude nor the fluctuation of their signs gives token, even in this case, of any such discordance between the formula and the true law of variation as Dr. Wild thinks he has discovered for the Russian stations. Here at least it may be said of the daily curve, "Natura non facit saltum." As regards the magnitude of the residuals, no one can be more conversant than Dr. Wild with the numberless influences which, in spite of every care, affect the accuracy of observations, nor yet with those analogous ones in the varying and intricate combinations of transient atmospheric conditions, which by their perturbations throw a veil over the true fundamental law. And I think he cannot fail to acknowledge that the true law is here expressed by the sine-formula closely

enough to justify its employment for places in this region where the number of daily observations is very much smaller. In order to show the relative as well as the absolute amount of residuals, I have appended the mean amplitude of the observed daily variation for each month.

Finally I am quite ready to concede that, although the mean daily variation in Cordoba follows with much regularity the law expressed by a few terms dependent upon sines of angles proportional to the time of day, it is by no means improbable that in higher latitudes and different circumstances this may not be the case; inasmuch as the simplicity of the law and its corresponding formula may there be essentially affected by perturbations which are not manifest here. Yet even in such case it would be difficult to justify, either from a scientific or from any other point of view, such remarks as those cited at the beginning of this article.

If the efforts of meteorologists to raise their study to the rank of an exact science are to attain that success for which the progress during recent years justifies a hope, this can only be accomplished through the aid of algebraic generalization. The frequent misuse of a method affords no argument against its legitimate employment.

I could wish that these few remarks might tend to convince the eminent Russian meteorologist, that in his zeal against the misuse of the so-called Bessel formula, he is in danger of taking a backward step and obstructing the progress of meteorology by opposing his great influence to the custom of algebraic generalization, which is a necessary condition for the advance of the science from the descriptive to the exact stage. Yet even though this hope should prove unfounded, I cannot but think that he will perceive the very great injustice which he has done to my work. Although there is, under the especial circumstances of the case, a certain grim humor in the imputation of a needless waste of time and labor in deducing illusory results, I shall not allow myself to be drawn into any personal considerations.

But in any case, I must express the earnest hope that the comparatively modern usage of generalizing meteorological results to the utmost by means of algebraic formulas may be stimulated and encouraged in every way.

Cordoba, Argentine Republic, November 9, 1879.

ART. XXVIII.—*On the Chemical Composition of the Uraninite from Branchville, Conn.;* by W. J. COMSTOCK. (Contributions from the Laboratory of the Sheffield Scientific School. No. LVIII.)

THE composition of uraninite, or pitchblende, has never been satisfactorily established, although the formula $U_3O_8=UO_3+2UO_2$, suggested by Rammelsberg, has been generally accepted. The presence of the other elements, shown in the different analyses, has been explained by assuming that the material analyzed was impure. Professors Brush and Dana obtained during their recent explorations at Branchville,* small isometric crystals having a specific gravity of 9·22–9·28, which reacted with the fluxes for uranium, and yielded upon reduction before the blowpipe a globule of lead. They identified the mineral with uraninite and suggested the probability that the lead entered into its composition. The material for analysis was handed to me by them.

The crystals occurred in a small vein in albite; there was nothing with which they could be confounded, and hence the purest material was available for analysis. A few crystals had a thin yellow coating, probably of uranium phosphate. The crystals were all octahedral in habit, in most the planes of the dodecahedron appeared, and in a few cases, those of the cube. The mineral is readily soluble in nitric acid, yielding a yellow solution, but it is not acted upon by hydrochloric acid. It decrepitates on heating and gives off traces of moisture. When heated strongly in an open tube it has a very slight acid reaction on litmus paper. An analysis showed the mineral to have the following composition:

	I.	II.	Mean.
U =	81·67	81·33	81·50
Pb =	4·01	3·94	3·97
Fe =	·41	·39	·40
O =	13·37	13·47	13·47*
H_2O =	·88		·88
Total			100·22

* For the oxygen, the determination in No. II is used, as it was made with greater care.

The uranium, lead and iron were separated and weighed according to the ordinary methods. The water was driven off by ignition and determined by absorption in a calcium chloride tube. The oxygen was determined by decomposing the min-

* This Journal, III, xvi, 35, July, 1878.

eral with sulphuric acid in a sealed tube and titrating with a solution of potassium permanganate, thus affording with the uranium, lead and iron determined, all necessary data for calculation. That this method can be employed with accuracy in presence of both UO_2 and UO_3 was first proved by experimenting upon pure U_3O_8. The best results were obtained by boiling the sulphuric acid used to expel the air, and displacing the air in the tube by CO_2 before sealing. The following are the results obtained.

	Taken.	Found.
1.	·5160 U_3O_8 containing ....·1655 UO_2	·1647 UO_2
2.	·5016 U_3O_8 " ....·1608 UO_2	·1599 UO_2

Assuming the state of oxidation in which the lead and iron exist in the mineral, the percentages of UO_2 and UO_3 can be calculated from the data furnished by the permanganate titration. The most probable assumption is that they exist as PbO and FeO, replacing the UO_2 by equivalent amounts of $(PbO)_2$ and $(FeO)_2$. The analysis then becomes:

				Ratios.	
UO_3	=	40·08		·1392	·1392
UO_2	=	54·51		·2004	
PbO	=	4·27	$(PbO)_2$	·0095	·2133
FeO	=	·49	$(FeO)_2$	·0034	
H_2O	=	·88			
Total		100·23			

We shall then obtain the ratio—

$$\overset{\text{IV}}{R}O_2 : \overset{\text{VI}}{R}O_3 = ·2133 : ·1392 = 1·53 : 1 = 3·06 : 2$$

and the composition of the mineral will be represented by the formula—

$$3\overset{\text{IV}}{R}O_2 + 2\overset{\text{VI}}{R}O_3$$

in which the $\overset{\text{IV}}{R}$ represents tetrad uranium replaceable by two atoms of lead or iron, and $\overset{\text{VI}}{R}$, hexad uranium.

It is also possible that the iron exists as Fe_3O_4, which, like pitchblende, crystallizes in the isometric system. But under that supposition, the ratio of 3 : 2 would not be essentially changed.

When the mineral is heated in air, it is to be expected that the uranium would be oxidized to the state of U_3O_8, and the iron to Fe_2O_3. Calculated from the analysis, the gain in weight by this oxidation would amount to 1·48 per cent its weight. In determining the water, the mineral was found to weigh ·57 per cent more after ignition; this, added to the water expelled, gives 1·45 per cent.

The mineral may then be considered as a basic uranous uranate, in which the basic uranium is replaceable by lead (and iron). That the uranium exists in pitchblende as U_3O_8, has been assumed without proof; the only related crystallized mineral heretofore analyzed is the questionable uranoniobite of Scheerer, who gives 15·6 p. c.=PbO,Nb_2O_5 and SiO_2, and 2·7= loss.

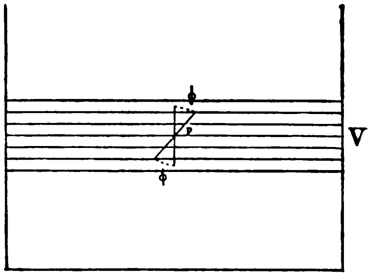
The acid reaction shown in the tube is unexplained. It was first attributed to sulphur, but by careful examination none could be detected.

ART. XXIX.—*On the Mean Free Path of a Molecule*; by N. D. C. HODGES.

THE free path of a molecule is dependent on the amount of obstruction it meets with, on the density of the medium. Meyer gives for the mean free path on page 308 of his Kinetische Theorie der Gase, $L=\frac{1}{\pi\sqrt{2}N\xi^2}$. Here N is the number of molecules in the unit volume.

I consider the length of path in a medium of variable density. At the surface of a liquid, if there is no sharp transition from the liquid to the gaseous state, we shall have a succession of less and less dense vapors from where there is liquid to the surrounding atmosphere. The layers V (fig. 1) are what I refer to. The depth of these vapors, is of course, much magnified.

1.



I propose to find the pressure upon the particle, p, when the surface of the liquid is plain and when it is spherical. Taking molecules moving with any definite velocity, they will reach p and give it an impulse, when they are at a distance from p less than their mean free path. Now, the particles from below come from denser layers than those from above. A greater number will come from below than from above; there will be a tendency to drive p upward. To find this tendency, we must find

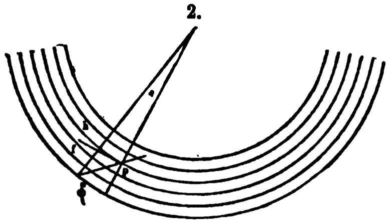
how much denser the lower layers, from which molecules impinging on p come, are than those above, from which particles come to p. If $\delta\rho$ is the obstruction met by a molecule in passing vertically upward through a single layer, $\frac{\delta\rho}{\cos\varphi}$ will be that met in the direction at an angle φ with the vertical. The integral $\frac{1}{\cos\varphi}\int_{\rho_0}^{\rho_1} d\rho$ gives the obstruction met by the molecule from one end to the other of its path. This integral must be constant, for the length of path is independent of the direction. As the differential of the obstruction is the same as the differential of the density,

$$\frac{1}{\cos\varphi}\int_{\rho_0}^{\rho_1} d\rho = \frac{\rho_1 - \rho_0}{\cos\varphi}$$

when ρ_0 is the density at the point p and ρ_1, that at the other end of the path. As $\frac{\rho_1 - \rho_0}{\cos\varphi} = \varkappa$, the numerator $\rho_1 - \rho_0$ must be proportional to $\cos\varphi$. The pressure on p is proportional to this difference, and the resultant component in the upward direction to $\cos^2\varphi$.

When the surface is spherical (fig. 2), each element of the path offers an obstruction expressed by $\frac{\delta\rho}{\cos(\varphi - \frac{1}{2}\alpha)}$ for the parts below p, and by $\frac{\cos(\varphi + \frac{1}{2}\alpha)}{\delta\rho}$ for those above p, α is the angle between the radius of curvature at the point p and that to the

2.



other end of the path. $\varphi - \frac{1}{2}\alpha$ is the mean value of the angle between the direction of the path and the normals to the surfaces of equal density for the parts below p, and $\varphi + \frac{1}{2}\alpha$ the corresponding angle for those above p.

Integrating, $\frac{\rho_1' - \rho_0'}{\cos(\varphi - \frac{1}{2}\alpha)} = \varkappa = \frac{\rho_0' - \rho_2'}{\cos(\varphi + \frac{1}{2}\alpha)}$. This shows that, whereas the difference in density above and below was the same for a plane surface, in the case of curved surfaces the pressure from below is greater, and that upward less. Or the pressure from below is greater, and that from above greater. This must cause a greater density at p.

The tendency for a particle to move from the liquid into the surrounding atmosphere is due to the difference in density of its liquid and of its vapor. For small changes in the density, the change in this tendency may be assumed as proportional to the change of density. It must be found what change in density takes place at p. As the change in density is due to an increase of pressure on p, this increase must be equal in all directions. So it is only necessary to consider one direction. Take the direction tangent to the curved surface at p. The increase in pressure is, therefore, proportional to the difference in density of the layer through f and that through h, or to the length fh. It is evident that $\frac{fh}{L}=\frac{\frac{1}{2}L}{r}$, when r is the radius of curvature, and L the length of the mean free path.

Hence we have $\frac{\text{the change of tension}}{\text{the tension of the vapor at plane surface}}=\frac{\frac{1}{2}L}{r}$

Sir William Thomson has shown that the change in tension at a curved surface is equal to the pressure of a column of the vapor of the height to which the liquid would rise in a capillary tube of a diameter of twice the radius of curvature of the surface.

In a tube of diameter $1{\cdot}294^{mm}$ water rises to a height of $23{\cdot}379^{mm}$. The data for the calculation are:

Weight of a liter of water vapor (at 100° C.)	·80357 grams
" " mercury	13·579 "
Tension of water vapor at 20° C.	$18{\cdot}495^{mm}$

The height of a column of mercury equivalent to the column of water vapor of height $23{\cdot}379^{mm}$ is

$$\frac{\cdot 80357}{13{,}579},\ 100,\ \frac{18{\cdot}495}{760},\ \frac{23{\cdot}379}{100}$$

The first factor is the fraction of a liter of mercury which a liter of water equals. The second reduces the height of this to millimeters. The third gives the result at 20° C., supposing the vapors to follow Boyle's law. The fourth is the fraction of a liter there was to be considered.

The expression for the mean free path in these surface vapors is then

$$\tfrac{1}{2}L=\cdot 647\frac{\cdot 80357}{13{,}579},\ 100,\ \frac{18{\cdot}495}{760},\ \frac{1}{18{\cdot}495}\ \frac{23{\cdot}379}{100}\ r=\cdot 647.$$

This gives $L=\cdot 0000024^{mm}$.

If the law according to which the density of the vapors vary with the depths was known, the free path of a molecule in a gas at the ordinary pressure could be found.

Physical Laboratory, Harvard College, Cambridge, U. S. A., January 27, 1880.

ART. XXX.—*On the Western Limits of the Taconic System;* by S. W. FORD.

SINCE the publication of my paper entitled "Notes on the Primordial Rocks in the vicinity of Troy, N. Y. (this Journal for July, 1871), Professor Dana has repeatedly urged that the Troy Primordial beds, together with those of Bald Mountain, Washington County, and their equivalents farther northward in Vermont and Canada, should not, in strictness, be referred to the Taconic, inasmuch as they were added by Dr. Emmons to his Taconic System several years subsequent to its original definition, and upon insufficient grounds. In this view I have always acquiesced, partly because of its essential justness, and partly because of the endless disputes and controversies which its adoption seemed to me calculated to prevent. In my paper referred to, the Troy beds are spoken of by me as part of the Taconic System, not, however, as a believer in the system, but because they appeared to me to have a better right to this title than to any other that had previously been applied to them. The Taconic System, as a system distinct from the Silurian, has appeared to me from my earliest knowledge of it, of questionable standing; but the chances in favor of its general acceptance seemed to me quite as good so long as it rested within the limits originally assigned to it. In extending his system westward, in 1846, from Petersburg, N. Y., to the Hudson River, Dr. Emmons certainly had the remarkable uniformity of dip and conformability of the rocks over the region studied in his favor; but when he found himself under the necessity of assuming an inversion of the whole system in order to get the black slates of Bald Mountain (in which Trilobites had then recently been discovered) at its summit, grave doubts were justly raised respecting the correctness of his interpretations.

I have no doubt that, to many, this assumption in itself (the typical region considered by Emmons being not far from 45 miles wide), has all along been regarded as practically fatal to the Taconic cause. We now know, thanks to the earnest and enlightened researches of Wing, Dana, Billings, Dale, and others, that the true Taconic rocks represent the Champlain Division at least from the Calciferous to the Hudson River group inclusive, and possibly the division entire; but with regard to the North-and-South belt added to them in 1846 (or that lying between Petersburg and the Hudson), while a considerable part of it has been shown to be Primordial, the age of by far its greater portion is still in doubt. How far the Primordial beds which come up at Troy and Bald Mountain are continued eastward as surface rocks, it is impossible at present to say. To

my mind, one of Dr. Emmons's greatest services to the cause of science was his recognition of the great stratigraphical break running east of the Hudson River by which the Primordial rocks were made to stand above those at the top of the Lower Silurian, and his advocacy of it in spite of the adverse paleontological determinations of Professor Hall, who referred the whole at first to the Hudson River group, and subsequently, at least in part, to the Quebec. Dr. Emmons's pronounced antagonism to the Hudson River doctrine grew, in this case at any rate, out of his appreciation of fundamental differences; and for this signally good work, notwithstanding the failure of his favorite system, he should ever receive, it seems to me, the grateful recognition of all workers in the department.

New York, February 5, 1880.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Vapor-density of Chlorine.*—Victor Meyer has replied to the criticism of Seelheim* upon his experiments on the vapor-density of chlorine at high temperatures. The platinous chloride which was used was heated in a boat. After the operation, this boat contained a rod of solid coherent platinum sponge, having the form of the vessel. Removed with care, its weight was almost precisely that calculated from the $PtCl_2$. No trace of sublimed or crystallized platinum could be detected. As to the experiments of Troost and Hautefeuille, it is difficult to see how platinum heated to a yellow heat in chlorine, is perceptibly volatile, due to the formation of platinic chloride, since platinic chloride is completely dissociated at 600° C. As in all similar reactions, time is of course an important factor; but the author found that a weighed quantity of platinum heated for an hour to about 1570°, in an active current of dry chlorine, lost scarcely one per cent. Hence it can scarcely be supposed that the quantity of metal volatilized during the few seconds required for a vapor density determination, with no gas current, would be at all appreciable.—*Ber. Berl. Chem. Ges.*, xii, 2199, Dec., 1879.

G. F. B.

2. *On the Action of Phosgene gas on Ammonia.*—Fenton has examined the white amorphous substance which is produced when phosgene gas ($COCl_2$) acts upon ammonia, with a view to ascertain whether the urea contained in it is the ordinary form of this body or an isomer of it. For the preparation, the two thoroughly dried gases were brought together in large flasks, the phosgene being prepared by passing carbonous oxide through

* This Journal, III, xix, 65, Jan., 1880.

boiling antimonic chloride. A portion of the white solid was examined by Bouchardat's method, and crystals of guanidine sulphate were prepared from it. Another portion was evaporated to dryness with excess of barium hydrate in vacuo over sulphuric acid, the residue was extracted with absolute alcohol, the solution evaporated to dryness on a water bath, dissolved in water, treated with CO_2, evaporated and digested with absolute alcohol. On evaporation of the alcohol crystals were obtained having all the appearance of urea. Treated with sodium hypobromite and hypochlorite, the nitrogen evolved was nearly twice as much with the hypobromite. Evaporated with silver nitrate, silver cyanate crystallized out. Heated in a tube, ammonia was evolved and the residue gave a strong reaction for biuret. Heated to 40° with urea ferment, its solution became alkaline and gave off ammonia. Nitric acid and mercuric nitrate gave their characteristic reactions. Hence the substance obtained is identical with ordinary urea. Direct tests showed that this urea existed as such in the original white powder, and hence rendered it probable that its isomer, the symmetrical carbamide $CO\left\{\begin{matrix}NH_2\\NH_2\end{matrix}\right.$ is not formed in the reaction.—*J. Chem. Soc.*, xxxv, 793, Dec. 1879. G. F. B.

3. *On the Hydrocarbon Fluoranthene.*—FITTIG has published, in conjunction with LIEPMANN, a second paper upon fluoranthene, a hydrocarbon discovered by him in 1875 and described in 1878. It occurs among the more solid products of the final distillation of coal tar, and has the formula $C_{15}H_{10}$, intermediate between phenanthrene $C_{14}H_{10}$ and pyrene $C_{16}H_{10}$. Separation from pyrene by the fractional crystallization of the picrates being tedious, fractional distillation in a partial vacuum was resorted to with success. The vapor density of the pure fluoranthene was 6·638, theory requiring 6·574 for $C_{15}H_{10}$. On oxidation with chromic acid, diphenyleneketone-carbonic acid is the principal product, mixed, however, with a quinone. By conducting the operation with care, a mixture is obtained on the filter, of the acid, the quinone, and the unattacked hydrocarbon. Removing the acid with sodium carbonate and dissolving the residue in hot alcohol, long, flat, ruby-red, brilliant needles of a compound of the quinone with fluoranthene $C_{15}H_8O_2+(C_{15}H_{10})_2$ separate on cooling. Treatment with hydro-sodium sulphite dissolves the quinone, leaving the hydrocarbon. The quinone crystallizes from alcohol in small red needles, fusing at 188°. Diphenyleneketone-carbonic acid resists oxidation energetically, and hence may be prepared from the crude product from the press. Treated with fuming nitric acid at a gentle heat it gives mononitro-diphenyleneketone-carbonic acid. Fused with potassium hydrate, it gives isodiphenic acid, $C_{12}H_8\left\{\begin{matrix}COOH\\COOH\end{matrix}\right.$ or $\left\{\begin{matrix}C_6H_4COOH\\C_6H_4COOH\end{matrix}\right.$, which on oxidation gives isophthalic acid, $C_6H_4\left\{\begin{matrix}COOH\\COOH\end{matrix}\right.$. Suspended in water, and treated with sodium amalgam, diphenyleneketone-carbonic

acid yields a carboxyl derivative of diphenylenemethane (fluorene), which the authors call fluorenic acid, $\begin{matrix} C_6H_4 \\ | \\ C_6H_3-COOH \end{matrix}\!\!>\!CH$. This acid, distilled with lime gives the hydrocarbon fluorene $\begin{matrix} C_6H_4 \\ | \\ C_6H_4 \end{matrix}\!\!>\!CH_2$. Oxidation by chromic acid destroys fluorenic acid, but with permanganate in an alkaline solution, diphenylene-ketone-carbonic acid is formed. From these data the authors assign to fluoranthene the formula $\begin{matrix} C_6H_4>CH-CH \\ | \qquad\qquad \| \\ C_6H_3 \text{———} CH \end{matrix}$, and to diphenyleneketone-carbonic acid $\begin{matrix} C_6H_4 \\ | \\ C_6H_3-COOH \end{matrix}\!\!>\!CO$, isodiphenic acid being as above given.—*Liebig's Ann.*, cc, 1, Dec. 1879. G. F. B.

4. *On the Introduction of Hydroxyl by Direct Oxidation.*—R. MEYER and A. BAUR have examined the possibility of converting cumene-sulphonic acid into an oxyacid by direct oxidation while its isomer, propyl-benzene-sulphonic acid resists this action. Normal propyl-benzene was converted into the sulpho-acid, and this, first into the barium and then into the potassium salt. The latter, submitted to permanganate, in solution of potassium hydrate, gave only carbonic acid, the greater part of the salt remaining unchanged. Cumene from cuminic acid was converted into cumene-sulphonic acid, and the potassium salt was submitted to oxidation as in the previous case. A product resulted which was markedly more soluble in alcohol than the salt used, and which afforded on analysis the formula $C_6H_4\begin{cases} C_3H_7O \\ SO_3K \end{cases}$. Consequently the oxidation had resulted in the substitution of an atom of hydroxyl for one of the hydrogen atoms in the lateral isopropyl chain, producing oxypropylbenzene-sulphonic acid $C_6H_4\begin{cases} C_3H_6OH \\ SO_3H \end{cases}$. These results are a new confirmation of the view that only hydrogen atoms which occupy tertiary positions can be changed into hydroxyl by a direct oxidation, the isopropyl group containing one such hydrogen atom, the propyl group none.—*Ber. Berl. Chem. Ges.*, xii, 2238, Dec. 1879. G. F. B.

5. *On the Constitution of Dibromethylene.*—There are two bodies of the formula $C_2H_2Br_2$; one acetylene dibromide, and the other dibromethylene. One of these bodies must be symmetrical and have the constitution $\begin{matrix} CHBr \\ \| \\ CHBr \end{matrix}$; the other must be unsymmetrical, and be $\begin{matrix} CH_2 \\ \| \\ CBr_2 \end{matrix}$. Anschütz has demonstrated that it is the acetylene dibromide which is symmetrical, and hence, by inference, the dibromacetylene must be unsymmetrical. To establish this question experimentally, DEMOLE has made use of the fertile

discovery of Friedel and Crafts, that aluminum chloride remarkably facilitates the substitution of a hydrocarbon radical for a haloid element, and mixed together 28 grams dibromethylene with 150 grams benzene, adding gradually to the mixture from 40 to 50 grams of Al_2Cl_6. Hydrobromic acid was disengaged, the reaction proceeding quietly. On fractioning the hydrocarbons obtained two products were collected, one boiling from 270° to 290°, and the other above 350°. The former was an oil, colorless, highly refractive, of an agreeable odor, having the formula $C_{14}H_{12}$, or that of stilbene or diphenyl-ethylene. Its boiling point, and its state as a liquid show it to be the dissymetrical stilbene of Hepp. To prove this dissymetry still further, it was oxidized with chromic acid, saturated with sodium carbonate, and the crystallized sodium salt distilled. The substance obtained boiled at 295°-300°, crystallized on cooling in large white rhombic prisms, fusing about 48°, and was therefore pure benzophenone, $CO\left\{\begin{matrix}C_6H_5\\C_6H_5\end{matrix}\right.$.—*Bull. Soc. Ch.*, II, xxxii, 547, Dec. 1879. G. F. B.

6. *On the Archil-lichens of California.*—HESSE has submitted the archil-producing lichens obtained from California to a chemical examination. He gives the Neue Freie Presse of Vienna credit for the statement in 1871 that 300 persons had gone from New York to Lower California to collect these lichens then lately discovered. They were found on hard, rocky soils near the coast, and a single person could collect a ton, valued at 300 dollars, in four days. In the year 1870 the archil sold in the United States from this source was valued at $14,900, and the extract prepared from it at $4,700. The lichens found their way to the London market, and specimens reached him late in 1871. They had been pronounced to be the well-known lichen *Rocella tinctoria;* but doubting the correctness of this view, Hesse sent specimens to Laurer, the lichenologist, who answered by letter that it appeared to be new, and proposed for it the name *Rocella frutectosa*, placing it between *R. tinctoria* and *R. fuciformis* and nearer the latter. Hesse himself placed it as a variety of *R. fuciformis*. The lichens were extracted with milk of lime, the lime was thrown down by carbon dioxide gas, and the chromogen was purified by crystallization from hot alcohol. When pure it exhibited all the properties of β-erythrin, and gave on analysis the same formula, $C_{20}H_{22}O_{20}$. It is optically inactive and yields picroerythrin and orsellinic ether when decomposed by alcohol. Beside erythrin, the lichen contains very small quantities of rocellic acid. The author regards this as confirmatory of his view as to the species.—*Liebig's Ann.*, cxcix, 338, Nov. 1879. G. F. B.

7. *On the Determination of Sulphur in Coal.*—NAKAMURA, a student in the Engineering College in Tokio, has devised a new process of determining sulphur in a coal, which seems to work well. It consists in heating the coal below a red heat in contact with alkaline carbonates, by which the coal, whether bituminous or not, rapidly undergoes, without evolution of smoke, complete

atmospheric oxidation in a manner hardly to have been expected. To one part of coal in very fine powder take three or four parts of the mixed alkali-carbonates. Mix intimately in a platinum dish and heat at first gently, using alcohol in place of gas to avoid the sulphur of the latter. Raise the heat very slowly, not reaching a visible red until the surface of the mass becomes faintly gray. Then heat to a faint red, and keep it there for an hour, when the mass will be nearly or quite white. It is then treated with water, filtered, and the sulphuric acid determined in the filtrate as usual. The complete combustion of coal and coke at so low a temperature is noticeable. The carbonate seems to exert no chemical action in the case, but acts mechanically, apparently the spaces between the particles allowing a draft of air, and the combustion proceeding from the bottom toward the top. Direct experiment shows no loss of sulphur, and comparative tests prove the results to be accurate. The complete roasting process occupies about an hour and a half.—*J. Chem. Soc.*, xxxv, 785, Dec. 1879. G. F. B.

8. *A Theoretical and Practical Treatise on the Manufacture of Sulphuric Acid and Alkali, with the Collateral Branches;* by GEORGE LUNGE, Ph.D., F.C.S., Professor of Technical Chemistry at the Federal Polytechnic School, Zurich (formerly manager of the Tyne Alkali Works, South Shields), London, 1879. Vol. I, pp. 658, 8vo. (John Van Voorst).—Dr. Lunge, in his volume on Sulphuric Acid, explains in full detail, not only the practical steps of the manufacture, but discusses, as only a good chemist can, the theoretical questions involved in the various processes. The work is illustrated with plans drawn to scale, of every part of all the apparatus required, and such clear directions as to construction, and such minute instructions as to operating are given that the book is a complete guide to the manufacturer.

Since the first decade of this century, when sulphurous acid was first conveyed in a continuous stream into the lead chamber, and the steam jet was introduced, and the operation thus made unintermittent, the main features of this, the most important of all the chemical industries have remained unchanged. But the ingenuity of manufacturers has found ample scope in discovering other sources of sulphur than crude brimstone, and devising suitable furnaces for burning them in, and in contriving means for reducing to the utmost the loss of sulphur and nitrogen. Iron pyrites, and, to a limited extent, other sulphuretted minerals and other metallurgical products, have displaced brimstone in most European works. This change was begun in 1838, when the Sicilian Government, by unwisely raising the price of brimstone, drove acid makers to seek a substitute; and it has been consummated by the introduction, since 1860, into every European market of the copper-bearing pyrites of Spain, whose profitable yield of copper allows of a very low price being charged for its sulphur contents. Of this important mineral not less than 600,000 tons are imported annually into Great Britain alone, prima-

ily for the manufacture of acid; but 20,000 tons of metallic opper are extracted from it by leaching—a not inconsiderable lye roduct. Dr. Lunge expresses surprise that similar mineral, which he supposes to abound in many localities on this side the Atlantic, has not here also taken the place of brimstone. The eason is that no mineral, as suitable, does exist within availble distance of our manufacturing centers. It is a question whether Spanish and Portugese pyrites might not be profitably urnt by the Atlantic coast works of the United States. Toward decision of this question, Dr. Lunge offers ample data by canidly discussing the advantages and disadvantages of brimstone nd pyrites respectively as a source of sulphur, and by describing he modifications in plant which the change involves.

Another topic to which Dr. Lunge devotes several chapters, and which merits the consideration of our manufacturers—as there is ome misapprehension on the subject—is the best method of addng the nitre and the most efficient mode of preventing its loss. Everywhere the Gay Lussac tower is used to absorb by means of ulphuric acid the nitrous acid escaping from the last chamber; ut our manufacturers do not seem yet to have recognized the ull value of the Glover tower, when placed between the burner nd the first chamber. There is an opinion prevalent that if the ulphurous acid from the burner be used in the tower to decomose the nitrosulphuric acid, the temperature is raised to a degree ufficient to liberate nitrogen and far above that at which the ases should enter the chamber. Dr. Lunge, who was one of the irst manufacturers to adopt the invention which Mr. Glover reely offered to the public, shows conclusively that these objecions were not valid, and describes how the Glover tower is not nly the best denitrificator, but a most economical concentrator f chamber acids, and the most desirable point in the circuit at which to add the nitre.

Full descriptions are given of Faur & Kessler composite platiium and lead stills, and of the modifications in shape, with consequent reduction in weight, which this innovation has driven the ld platinum-still makers to adopt.

All the volume needs is an index, which, strange to say, is alogether wanting. J. DOUGLASS.

9. *The Chemistry of Common Life;* by the late JAMES F. W. JOHNSTON, Professor of Chemistry in the University of Durham, etc. A new edition, revised and brought down to the present ime by A. H. CHURCH, M.A. 592 pp., 8vo. New York, 1880. D. Appleton and Co).—A great advance has been made since the ublication of the first edition of this work, by Professor Johnson, twenty-five years ago, both in the science of Chemistry itself nd in the extent to which the general public is familiar with its rinciples. The novelty of the discussions is consequently not now so great as then, but on the other hand the general interest elt in them is probably greater. This clear exposition, by Proessor Johnston, of the many points in which Chemistry touches

every-day life, has been and will still be, the means of doing much good. The editor, Professor Church, has brought the book down to the present time, but throughout, as he states, with the design to respect both the method and style of the original work.

10. "*Why the Air at the Equator is not Hotter in January than in July;*" by A. Woeikof (St. Petersburg).—In Nature, vol. xxi, p. 129,* Mr. Croll gives his reasons why the equator is not much warmer in January than in July, notwithstanding the greater nearness of the sun at the former season. To state the case briefly, he, having recalled the fact that the whole earth is colder in January than in July, because in the former the cold winter of the northern (or principally land) hemisphere coincides with the mild winter of the southern (or principally water) hemisphere, he continues: "Consequently the air which the equatorial regions receive from the trades must have a higher temperature in July than in January. The northern is the dominant hemisphere; it pours in hot air in July and cold air in January, and this effect is not counterbalanced by the air from the opposite hemisphere. The mean temperature of the air passing into the equatorial regions ought therefore to be much higher in July than in January, and this it no doubt would be were it not for the counteracting effects of eccentricity." And further: "There is another case which must also tend to lower the January and raise the July temperature of the equator: the northern trades pass farther south, and consequently cool the equatorial regions more during the former than the latter season."

I maintain that there is no such influence of the northern trades on the temperature of the equator, because they scarcely anywhere reach it, and then because the lower latitudes of the northern hemisphere are not colder in January than those of the southern hemisphere in July. *In the Atlantic the northern trades do not reach the equator at all in January*, but only in February, March and April, and this but in the western part of the ocean. The same may be said of the Pacific in its eastern part, where alone the trades are regular. In the Western Pacific, as well as in the Western Indian Ocean, I admit that air from the northern hemisphere reaches to the equator and somewhat beyond in January but not that this tends to give the equator a lower temperature in this month than in July. According to Dove, the mean temperature of 10° N. in January is 77°·2; of 10° S. in July, 76°·1.

So far as the temperature of the equator is concerned, the southern is the dominant hemisphere, and the equator is certainly cooled by winds coming from the south. If the equator is not everywhere warmer in January than in July, this is caused by the rainy season, which on the equator, and even a few degrees north of it, generally coincides with the southern summer. Where the rains are not very heavy, as, for example, on the Isle of St. Thomas, West Africa, we have: January, 78°·3; July, 75°·7; at Padang, Sumatra, where the rains are exceedingly heavy all the

* This Journal, February, 1880, p. 142.

ıere is scarcely any difference at all between the months. hat to the south of the equator, where to the difference in rness of the sun is added a much greater height above the in January, we have—

	January.	July.	Rainy Season.
na, Molucca Islands, 4° S.	80°·9	77°·4	May to August.
a, Java, 6° S.	77°·7	78°·8	December to February.
ıbuco, Brazil, 8° S.	80°·6	75°·0	April to July.

:he first-rate observations of Batavia, it is established that, s 6° S., January is 1°·1 colder than July, because the former rainy, while the latter has little rain. Even to 9° lat. N., colder than January, if the former has much more rain, example—

ıdo Po, W. Africa, 4° N.	79°·9	76°·5	March to November.
koro, Upper Nile, 5° N.	81°·3	75°·7	April to August.
wn, W. Africa, 8½° N.	80°·4	77°·0	June to October.

, in the lowest latitudes of the northern hemisphere, we ferences amounting to 5°·6, while in the southern greater ıces than 1°·1 are not known, which may, to a certain be ascribed to the nearness of the sun in January.

ak I have proved that, as to what we call the temperature air (really that of the lowest stratum), it is, on the equator ew degrees north and south from it, far more influenced yearly distribution of clouds and rain than by the differ-ount of heat received from the sun. The result would be ıt if we knew the temperature of the whole stratum of air. ating of the upper surface of the clouds by the sun, and lly the heat liberated in the condensation of water must the higher strata a superior temperature than that they the dry season; in other words, the decrease of tempera-th elevation is much slower during the rains than in the ıson, as was shown for India by Mr. Blanford. This is r other regions, and where the sky is cloudy and rains ınt in the greater part of the year, the temperature of the air may yet be higher than in drier climates, where the soil e lower stratum of air are hotter.

not agree with Mr. Croll in what he states at the end of er as to the effect of winds in cooling the equatorial regions ndering them habitable, as they would be too hot for man t the cool air brought from the temperate regions. I think oll has enormously over-stated the effects of winds on the ature of the equator. The extent of the tropical zone is so its temperature so very near to that of the equator, the which blow across it so gentle, that I consider the effect of nds from the temperate regions in directly cooling the tem-re of the equator to be nearly imperceptible. The follow-ı good illustration:—Nowhere is the winter temperature so ar the tropics as in Southern China, for example, in Janu-ınton, 55°·6, Victoria, Hong-Kong, 59°·2. Yet Saigon, in China, but 11° to the south of Hong-Kong, and subjected

to the full force of the northeast monsoon from the China seas, has a January temperature above 77°. Clearly the thermal effect even of the cold winter monsoon is scarcely perceptible farther south.

I consider water to be the only direct cause of the mildness and uniformity of equatorial temperatures, and this in three ways—(1) by the great heat-capacity of water; (2) by the clouds which interpose a screen between the sun and the surface of the earth; (3) by the evaporation of rain-water by the soil and plants.

The first cause is especially powerful on the ocean, while the two latter act especially on land, even very far from the sea. If it was not for the clouds and evaporation, how could we explain, for example, the absence of great heat (hottest month, 78°·6) at Iquitos, on the Amazons, 4° S., and more than 1,000 miles from the Atlantic, where the winds are generally weak?

As to the winds, I admit of their effect in this case; but (1) in causing ocean currents, and thus removing the heated water from the equator; (2) in spreading the cold air from over the cold currents over a greater distance. The latter is the cause of the low temperature in the equatorial regions of the Eastern Atlantic and Eastern Pacific.

Where the sky is clear and humidity and rains deficient, very high temperatures of the air are attained, even at a great distance from the equator (10°–30°) and this notwithstanding winds of considerable force blowing from cooler regions. So, for example, the north winds blowing in the summer in the Sahara, and coming from the cooler Mediterranean, are certainly stronger than the trades of the ocean and yet do not prevent the desert from attaining a higher temperature than known in any equatorial region.—*Nature*, Jan. 15.

11. *Report on Magnetic Determinations in Missouri in the Summer of* 1879; by FRANCIS E. NIPHER.—The magnetic survey of Missouri, commenced in 1878, was continued during the summer of 1879. Observations of the declination and inclination of the needle, and of the horizontal intensity, were made at a considerable number of new stations. The report gives the methods employed and the results of the observations in detail. A map is added giving the isogonic lines for both Missouri and Iowa, those of the latter State being based upon the survey by Dr. G. Hinrichs. These isogonic lines exhibit remarkable flexures, which are believed to bear an intimate relation to the drainage systems of the two States. Prof. Nipher offers the following explanation:

Assuming the existence of earth-currents of electricity, the general direction of which is from east to west, they distribute according to well-known laws, flowing in greatest quantity through the lines of least resistance. The magnetic needle tends to set at right angles to the current, following the well-known law enunciated by Ampère. Where the general direction of the moist river valley is at right angles to the normal position of the magnetic needle, the position of the latter is not changed, as the tendency of the needle is to set at right angles to a current of elec-

tricity. In such a valley (as, for instance, in the Missouri valley between Jefferson City and the mouth of the river), the direction of the needle should be normal, the direction in which the water flows being without (appreciable) effect. Where the river runs at right angles to the earth currents, the disturbing cause would be practically removed, as there would be no deflected component of the earth current along the river valley.

The maximum effect is produced in the case of rivers making an angle of 45 degs. with the general direction of the earth currents. Of course, this effect would be most marked where the river and valley are very large, as in the case of the Mississippi and Missouri, or where we have an immense drainage system consisting of long rivers and creeks running parallel and in the proper direction, as is the case on the eastern slope of Iowa.

Whether the explanation above suggested be the true one or not, the deflection of the 11° and 10° lines to the east in the western part of Iowa, the abrupt bends between St. Joseph and Kansas City and between Glasgow and Jefferson City, the westward bending of the 8° and 8° 30′ lines in the Osage Valley as compared with the 9° line in the same latitude and the remarkable flexures in eastern Iowa, are all in harmony with it.

12. *Variations in the Magnetic Declination deduced from observations made at Moncalieri (Piedmont) from* 1871–78.—The conclusions deduced by R. P. Fr. Denza in relation to the variations of the magnetic declination in Piedmont are as follows: The mean monthly variation of the declination attains a minimum in December. It increases at first slowly, from December to Febru-ry, and then more rapidly from February to April. The largest values are attained in April and June, the first of which is a little the larger. In the intermediate month of May there is a sensible diminution of the value. After attaining the maximum in June there is a second diminution during July and August slowly, and more rapidly in the autumn months to December.—*Comptes Rendus*, Jan. 12.

13. *On a new action of Magnets on Electric Currents;* by E. H. Hall.—In a letter from the author, received by the editors since the article on pp. 200–205 was printed, he states that the values of M, the strength of the magnetic field, given in the article should be multiplied by a constant factor which is nearly 2. The precise value of this reduction factor cannot be given, but the change does not affect the main conclusions arrived at. Mr. Hall adds that he hopes in a month or two to publish more exact numerical results in regard to the new action as observed in several different metals.

II. Geology and Mineralogy.

1. *Geology of the Rio São Francisco, Brazil.*—Mr. O. A. Derby, of the Brazilian National Museum, has recently been making, in company with a party of government engineers, a geological examination of the Rio São Francisco, from the falls of Paulo Affonso, to Januaria. From the latter place Mr. Derby was to proceed to Rio de Janeiro overland, by way of the rich mineral districts of Minas Geraes. The latest news from Mr. Derby is contained in a letter, dated near the city of Barra, on the São Francisco, November 9, 1879, which gives us a few general statements of interest, as to the result of his observations up to that time. From Paulo Affonso, the ascent of the river for eighty leagues was made in canoes, and then a small steamer was procured to accomplish the remainder of the journey. Cretaceous fossils, similar in character to those of the fresh-water basin of Bahia, were discovered in abundance, in the sandstone formation about Paulo Affonso. Leaving the sandstone region, they traveled for a long distance through a gneiss region, with occasional patches of itacolumite. This was succeeded by a region, composed mostly of itacolumite, which extended as far as they had gone; but two days out from the city of Barra, they came upon the horizontal limestones of the upper river, which Mr. Derby proposed to study with great care, in order to determine their geological age. So far they had yielded no fossils, but Mr. Derby was hopeful of finding at least some remains, as the beds are very well developed in certain localities, yet remaining to be visited. In closing, Mr. Derby remarks: "One thing is certain, we have got to give up the great Tertiary depression and greatly extend the area of the Cretaceous. I find that many of the beds, which have been described as horizontal and undisturbed, have really suffered upheaval, and are far from horizontal over large areas." R.

2. *Age of the Taconic rocks and Geology of Vermont, according to Professor C. H. Hitchcock.*—Professors Edward and C. H. Hitchcock, in describing the Taconic system (the slates, limestones, quartzyte, etc.) in the Geological Report of Vermont, after treating of its distribution, its rocks and its fossils, and apparently referring it on account of the fossils to the Lower Silurian, have, next, a closing section (on pages 446, 447) headed *Presumptions in favor of the Taconic System*, and in this section the conclusion is formally stated that the Taconic System underlies the Lower Silurian. I was led, therefore, in preparing the bibliographical note published on page 153 of this volume (and also in the new edition of my Manual of Geology, page 835) to place the Vermont Report with those works that make the Taconic beds pre-Silurian, as I had previously done when writing my articles on Vermont geology. In a letter from Professor C. H. Hitchcock, dated February 10th, he states that the "Presumptions" were introduced "as a brief exposé of the Taconic System, couched in such

language as Emmons himself would have used." It is with great satisfaction that I am able to make the correction and cite, from the same letter, the fact that "there is nothing in the Report anywhere favorable to Taconism," although, as he also writes, it does not refer the system distinctly to the Lower Silurian, except in the statement of paleontological facts that really support this view. On the earlier pages, 251 to 257, Professor Edward Hitchcock gives a section through the Taconic region and views as to the folds which accord fully with this opinion.

He says also that at the time when the fossils were discovered and submitted to Professor James Hall, just before the publication of the Report, it was Mr. Hall's opinion that the quartzyte was the Medina sandstone, and that the Taconic group was mostly above the Lower Silurian, and hence the reference of some of the fossils—none of them very distinct specimens—to the Upper Silurian.

Professor Hitchcock also says, in the recent letter to me, after remarking on his disbelief in "Taconism:" "Within the past two years I have gone over most of the Vermont sections, and have felt that they demonstrated the essential equivalence of the Taconic system with the Potsdam and the overlying limestones and slates [of the Lower Silurian]. I have been throughout in essential accord with you and Mr. Wing." He adds that Mr. Wing's views had been his for years.

This important correction was not received until after my article on the age of the Green Mountains (p. 191) was printed, or else this note would have been attached to it. J. D. DANA.

3. *A Monograph of the Silurian Fossils of the Girvan District in Ayrshire;* with special reference to those contained in the "Gray Collection," by H. ALLEYNE NICHOLSON and ROBERT ETHERIDGE, Jr. Fasciculus II. Trilobita, Phyllopoda, Cirripedia, and Ostracoda, pp. 137–233, with plates x–xv. Edinburgh and London: 1879. Wm. Blackwood & Sons.

4. *On Spodumene and its Alterations, from the granite veins of Hampshire County, Massachusetts.*—Mr. A. A. JULIEN has published recently (Annals N. Y. Acad. Sci., Nov., 1879), a valuable and extended memoir on spodumene and the results of its alterations. The two localities which are particularly described are those of Goshen and Chesterfield, Massachusetts. Analyses of pure and unaltered spodumene from these localities yielded the results given below. No. 1 was from the Levi Barrus farm in Goshen; specific gravity $=3\cdot19$. No. 2 from Chesterfield Hollow; specific gravity $=3\cdot185$ and $3\cdot201$.

	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Li_2O	Na_2O	K_2O	H_2O	
I	63·27	23·73	1·17	0·64	2·02	0·11	6·89	0·99	1·45	0·36	= 100·63
II	61·86	23·43	2·73	1·04	1·55	0·79	6·99	0·50	1·33	0·46	= 100·68

These closely agreeing analyses correspond very nearly to the formula $Li_2Al_2Si_4O_{12}$, for which the quantivalent (= oxygen) ratio

for $\overset{\mathrm{I}}{\mathrm{R}} : \overset{\mathrm{VI}}{\mathrm{R}} : \overset{\mathrm{IV}}{\mathrm{Si}} = 1 : 3 : 8$. This is the same formula recently deduced by Dœlter (see this Journal, xvii, 333, 1879), and though differing from the one before accepted, agrees with that obtained by Brush in an early analysis of the Norwich (now called Huntington) spodumene in 1850 (l. c. II, x, 370). The true composition of spodumene may consequently be accepted as established beyond a doubt. Mr. Julien remarks very justly that the specimens previously analyzed had doubtless suffered partial alteration, bringing with it a duller color and an inferior luster, translucency, hardness and specific gravity.

Much of the spodumene from the two localities mentioned, is altered into *cymatolite.* This name was given to a similar mineral from Goshen by Shepard, but the imperfect analysis published, with later that of Burton, left doubt as to the true composition of the species. This point has been very satisfactorily determined by Julien. The Goshen variety of cymatolite, previously called *aglaite* by the same author, occurs only as a continuation of the square prisms of spodumene, sometimes six or eight inches long, not as a coating over them. The structure is micaceous, the lamination flat, rarely undulating, and always in the plane of the orthodiagonal cleavage of the original spodumene. The laminæ are brittle but the thinner scales are flexible, somewhat elastic and transparent; they often project slightly beyond the sides of the crystal. The physical characters are: luster silvery to satin; color white; feel soft; hardness $= 1{\cdot}5$; specific gravity $= 2{\cdot}753$.

The Chesterfield variety is much more abundant. It occurs forming the whole, or with the original mineral a part, of crystals of enormous size; one is mentioned which was 35 inches in length while still lying in the vein and with a diameter of 10 to 11 inches. The structure is intermediate between micaceous and fibrous, with a strong wavy tendency of the foliation, on the surface of fracture. In the smaller crystals the plane of foliation is usually at right angles to the faces of the spodumene, and the folia therefore radiate from a central plane in the crystals which are completely altered; but in the larger ones, within a thin radiating crust of this kind, the folia generally conform to the central plane of cleavage of the spodumene and a parallel foliation often results. Sometimes a core of blackish-green pinite (killinite) is found in the smaller crystals; while in the larger crystals the core consists of spodumene often with killinite as a thin layer next to the white crust. A greenish-yellow muscovite is commonly intercrystallized in the larger pseudomorphs in scales or films. The hardness $= 1{\cdot}5$–2; specific gravity $= 2{\cdot}696$–$2{\cdot}700$; laminæ brittle. The following are analyses of cymatolite; 1, from the Manning farm and 2 from the Barrus farm, both in Goshen; 3 from Chesterfield Hollow.

	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Li_2O	Na_2O	K_2O	H_2O	CoO	
1.	58·51	21·80	0·85	0·29	1·44	0·84	0·19	6·88	6·68	2·40[1]	*tr*	=99·88
2. Aglaite	58·11	24·38	1·66	0·18	0·75	0·48	0·09	2·57	8·38	3·01[2]		=99·61
3. "	58·58	22·28	1·77	0·15	0·45	0·93	0·10	9·08	4·48	2·08		=99·90

[1] With nitrogenous organic matter 0·44. [2] do 0·43.

Two other analyses are also given; they agree closely with those here quoted, varying only as do these in the amounts of soda and potash. The calculated formula is $H_2(H, Na, K)_6 Al_8Si_{12}O_{37}$, which requires SiO_2 58·46, Al_2O_3 24·99, Na_2O 15·09, H_2O 1·46 = 100. It is shown that the formula is the same as that of spodumene except in the protoxide elements present and the additional molecule of water. Mr. Julien also describes in detail the microscopic characters of cymatolite, and from the fact of its greater atomic volume as compared with spodumene, argues that the process of alteration must have been accompanied with the exertion of a great pressure, the results of which are believed to be observed in many cases in the distortion of the pseudomorphs.

As mentioned above the variety of pinite called *killinite* also occurs as a pseudomorph after spodumene, though more sparingly than cymatolite. It has a foliated texture, retaining the cleavage of the original mineral. Hardness = 3·5, sp. gr. = 2·623–2·652. Luster dull and greasy to vitreous, the latter on the cleavage planes. Color greenish-gray to olive-green, also greenish-black; feel greasy. An analysis of the mineral from Chesterfield Hollow (G. = 2·623) yielded

SiO_2	Al_2O_3	FeO	MnO	CoO	MgO	CaO	Li_2O	Na_2O	K_2O	H_2O
46·80	32·52	2·33	0·04	0·04	0·48	0·77	0·32	0·78	7·24	7·66

Organic matter 1·14 = 100·12.

For this the formula $H_6K_2Al_4Si_6O_{20}$ is obtained or $H_2K_2Al_4Si_6O_{18}$+ 2aq. The original killinite is from Killiney Bay in Ireland; it corresponds closely with the Chesterfield mineral.

In addition to the above pseudomorphs, others after spodumene are described which consist:—(1) of vein *granite*, made up of muscovite, albite and quartz with large cymatolite columns passing from one end to the other of the mixture forming masses one hundred pounds or more in weight; (2) of greenish-yellow *muscovite*, more or less intermixed with cymatolite, it sometimes occurring only in minute, disseminated scales, and in others making up the whole of the pseudomorphous crystal, retaining the form and striations of the spodumene. These and the intermediate varieties are regarded as the results of intercrystallization of the two minerals, in the process of alteration: (3) of *albite*, generally intermixed with muscovite and quartz: (4) of *quartz*; these pseudomorphs are rare, and while retaining the form of the original mineral contain more or less mica. The last two forms are mentioned as varieties of (1) above.

Mr. Julien closes his very interesting paper with some remarks on the paragenesis of spodumene and the character of the alteration which has resulted in the formation of the pseudomorphs described. Two figures illustrate the relations of the several species.

5. *Crystals of Wollastonite.*—Professor O. ROOT mentions the discovery of very large crystals of wollastonite at Diana, New York; one crystal was upwards of eleven inches in length and ten inches across the prism, both terminations being complete. He has also obtained unusually large and perfect crystals of mica from the locality on the west bank of Vrooman Lake, N. Y.

III. Zoology.

1. *Fresh-water Rhizopods of North America;* by Joseph Leidy, M.D., Prof. Anat. Univ. Pennsylvania. 324 pp. 4to., with 48 colored plates. Washington, 1879. Vol. xii of the Reports of the U. S. Geological Survey of the Territories, F. V. Hayden, Geologist-in-Charge: Department of the Interior.—This new work, by Dr. Leidy, is a very important addition to the quarto series of reports connected with the Geological Survey of the Territories under Dr. Hayden. It is the result of a vast amount of careful microscopic research with regard to the structure, development and habits of these lowest forms of animal life over the North American Continent; and the numerous plates with crowded colored figures are attractive for their beauty, as well as for the instruction they impart.

Dr. Leidy shows in his descriptions and faithful delineations that he almost loved the little things, the study of which gave him so much pleasure. "In his concluding remarks," he says:—

"The objects of my work have appeared to me so beautiful as represented in the illustrations, and so interesting as indicated in their history which forms the accompanying text, that I am led to hope the work may be an incentive, especially to my young countrymen, to enter into similar pursuits. * * * 'Going fishing?' How often the question has been asked by acquaintances as they have met me, with rod and basket, on an excursion after materials for microscopic study. 'Yes,' has been the invariable answer, for it saved much detention and explanation; and, now, behold. I offer them the results of that fishing. No fish for the stomach, but as the old French microscopist, Joblet, observed, 'some of the most remarkable fishes that have ever been seen;' and food fishes for the intellect."

These fresh-water Rhizopods are of special interest to the philosopher, as well as the naturalist, because they belong to the lowest division of the animal kingdom—the higher section of the Protista of Hæckel—and yet are very decidedly animal in their characteristics, and wonderfully complex in their animal functions. As Leidy states (p. 5):

"The soft mass of protoplasm, or sarcode, forming the essential part of all Rhizopods, has no internal cavity like the body-cavity of higher animals, neither has it a mouth like the higher Protozoa, nor has it stomach or intestine. Without trace of nerve elements, and without definite, fixed organs of any kind, internal or external, the Rhizopod—simplest of all animals, a mere jelly speck—moves about with the apparent purposes of more complex creatures. It selects and swallows its appropriate food, digests it and rejects the insoluble remains. It grows and reproduces its kind. It evolves a wonderful variety of distinctive forms, often of the utmost beauty; and indeed, it altogether exhibits such marvelous attributes, that one is led to ask the question in what consists the superiority of animals usually regarded as much higher in the scale of life."

Dr. Leidy divides the Rhizopods into five orders: I. *Protoplasta*, II. *Heliozoa*, III. *Radiolaria*, IV. *Foraminifera*, and V. *Monera*; agreeing in this with the views of Professor L. E. Schulze, as brought out in a recent Number of the Archiv für Mikroscopische Anatomie (1877, p. 21). The Protoplasta and the Monera correspond to Hæckel's Protista. Excepting a few of the Monera section, fresh-water Rhizopods belong almost entirely to the Protoplasta and Heliozoa. All the fresh-water species described by Leidy are of these two groups, excepting one Foraminifer, named by Leidy *Gromia terricola*, the genus *Gromia* being exceptional among Foraminifera in that it is represented by several species inhabiting both salt and fresh water. The Protoplasta include the genera *Amœba*, *Difflugia*, *Nebela*, *Arcella*, and others; and the Heliozoa, *Actinophrys*, *Heterophrys* and others allied. With regard to Monera he says, "though Professor Hæckel has indicated and described a number of fresh-water species, I am not sure that I have had the opportunity of finding any of them, excepting perhaps the genus *Vampyrella* of Cienkowski, which he ascribes to the same order."

Dr. Leidy's experience enables him to give important information as to the localities of these species, and the best methods of collecting them. The following paragraphs taken from pages 8 to 11, are a part of his observations on these subjects:

"Fresh-water Rhizopods are to be found almost everywhere in positions kept continuously damp or wet, and not too much shaded. They are especially frequent and abundant in comparatively quiet waters; clear, and neither too cold, nor too much heated by the sun, such as lakes, ponds, ditches, and pools. They are also frequent in wet bogs and savannas, among mosses, in springy places, on dripping rocks, the vicinity of waterfalls, springs, and fountains, and in marshes, wherever the ground is sufficiently damp or moist to promote the growth of algæ. They are also to be found in damp shaded places, among algæ, liverworts and mosses, about the roots of sedges, rushes and grasses, or those of shrubs and trees growing in or at the borders of bogs and ponds or along ditches and sluggish watercourses. They are likewise to be found with algæ in damp shaded positions in the depressions and fissures of rocks, in the mouths of caves, among decaying logs, among mossses and lichens, on the bark of growing trees, and even in the crevices of walls and pavements about old dwellings and in cities.

"The favorite habitation of many kinds of Rhizopods is the light superficial ooze at the bottom of still waters, where they live in association with diatoms, desmids, and other minute algæ, which form the chief food of most of these little creatures. They never penetrate into the deeper and usually black mud, which indeed is almost universally devoid of life of any kind.

"Rhizopods also occur in the flocculent materials and slimy matter adherent to most submerged objects, such as rocks, the dead boughs of trees, and the stems and leaves of aquatic plants.

A frequent position is the under side of floating leaves, such as those of the Pond-lily, *Nymphæa odorata;* the Spatter-dock, *Nuphar advena;* and the Nelumbo, *Nelumbium luteum.* Certain kinds of Rhizopods, especially the Heliozoa, or Sun-animalcules, are most frequent among floating plants, such as Duck-meat, *Lemna;* Hornwort, *Ceratophyllum;* Bladderwort, *Utricularia;* and the various Confervas, as *Zygnema, Spirogyra, Oscillatoria,* and the Water-purse, *Hydrodictyon.*

"In no other position have I found Rhizopods of the kind under consideration in such profusion, number, and beauty of form as in sphagnous bogs, living in the moist or wet Bog-moss, or *Sphagnum.* Sometimes I have found this particular moss actually to swarm with multitudes of these creatures of the most extraordinary kinds and in the most highly developed condition. A drop of water squeezed from a little pinch of Bog-moss has often yielded scores of half a dozen genera and a greater number of species. Frequently, however, the Sphagnum of many localities contains comparatively few Rhizopods, though I have rarely found them entirely absent from this moss. Other mosses and liverworts I have not observed to be specially favorite habitations of the Rhizopods, not even such aquatic kinds as the *Fontinalis.*"

In water squeezed into a watch crystal from a small bunch of Sphagnum Dr. Leidy obtained thirty-eight species.

"The mode I have habitually adopted for collecting Rhizopods, which is also equally well adapted for collecting many other microscopic organisms, plants, and animals, is as follows:

For ponds, ditches, or other waters, I use a small tin ladle, or dipper, such as is commonly employed for domestic purposes. Into the handle I insert a stick of convenient length, and for this I usually carry with me a jointed pole of two or three pieces, each about five feet. The dipper is used by slowly skimming the edge along the bottom of the water so as to take up only the most superficial portion of the ooze, which is then gently raised from the water and transferred to a glass jar. A small hole in the bottom of the ladle favors the retention of the collected material, but care should be taken that it is not so large as to permit the material to stream through. After the collecting-jar is full, if more of the material is wanted, after allowing that in the bottle to settle, I pour off a portion of the water and supply an additional quantity from the locality.

"Usually, I have proved more successful in obtaining Rhizopods from the ooze near the shores of lakes and ponds than I have in deeper water; but this I suspect was mainly due to the circumstance that near the shore I could see the ooze at the bottom of the water, and could much better manage to collect the desired material.

"Aquatic plants, if rooted in the mud, should be carefully cut off and gently lifted from the water so as to disturb as little as possible the adherent materials. A sufficient quantity being placed in a tin preserving-can or other vessel, water from other portions of the plants may be squeezed upon that which is retained.

"Wet Sphagnum may be collected and put in tin preserving-cans, and the water of other portions may be squeezed upon the portion preserved. The same process may be pursued with other mosses.

"From the surface of the ground in wet places, to collect the Rhizopods, it is sufficient to scrape up, with the broad blade of a knife, the green algous material with which the animals are usually associated."

With regard to localities of marine Foraminifera along coast regions, he remarks, p. 17:

"Sea-sands contain as an important constituent the dead shells of recent Foraminifera, though in very variable proportions. They are generally most abundant in the sands of warmer latitudes, and especially on shores profusely furnished with sea-weeds.

"Plancus,* who, according to D'Orbigny, was the first to describe and figure the shells of Foraminifera, counted 6000 individuals in an ounce of sand from the Adriatic. D'Orbigny estimated that there were 160,000 in a gram of selected sand from the Antilles. Schultze gives 1,500,000 as the number he found in fifteen grams of sand from Gaeta on the coast of Sicily.

"Even on the comparatively barren shores of New Jersey, consisting of quartz sand, foraminiferous shells occur in notable quantity. In a portion scraped from the surface between tides, at Atlantic City, I estimated that there were 18,700 shells to the ounce avoirdupois, all of a single species of *Nonionina.* In another sample, from Cape May, I obtained 38,400 shells to the ounce, likewise of the one species.

"In sand collected by scraping up the long white lines on the bathing beach at Newport, Rhode Island, occupying an indenture of the rocky coast, covered with sea-weeds, foraminiferous shells were found to be much more numerous, but, excepting in the case of some examples of Miliola, of smaller size. In an ounce of the sand, I estimated that there were about 280,000 shells, of several genera and species."

One of the most remarkable forms described in the book is the *Dinamœba mirabilis*, from the Cedar swamps of New Jersey, represented by many figures on plates 6 and 7. It is commonly cream-white or greenish-white in color, but spotted often with green, brown, and yellow, all the colors, excepting the white, being due to the food-balls, which are chiefly the Desmids, *Didymoprium* and *Bambusina.* It is a gluttonous feeder, and is commonly so gorged with this vegetable food as to be more or less opaque. Every part of the surface, including the pseudopods and posterior papillæ, is ordinarily bristled with exceedingly minute spicules or ridged cils; but after some hours these may disappear or be represented by minute molecules. A still more remarkable feature is the occurrence of a thick investment of hyaline jelly, the outer surface of which is defined by innumerable, exceedingly

* Ariminensis de conchis minus notis. Venice, 1739.

minute rods, standing perpendicularly, which make the animal look as if surrounded by a nimbus of Bacteria. "In the movements of Dinamœba, its jelly-like cloak appears to be no obstacle, and the subulate pseudopods shoot through and beyond it as if it did not exist."

Another species of peculiar interest is *Hyalosphenia papilio*, a buff-colored, or straw-colored species, perfectly transparent, and remarkably constant in its form.

The species of Nebela, particularly *N. collaris*, *N. hippocrepis* and *N. ansata*, are of special beauty; but we must refer to the work with its plates, for the facts respecting these and the various other kinds. The book is adapted to the uninitiated as well as to adepts in the science. Dr. Leidy says, "In the course of its preparation, I have always had my pupils in mind, and I shall be glad if it serves as an additional aid to their studies;" and we add that it is well adapted to this and its higher purpose.

The work closes with a Bibliographic appendix, containing the names of authors of works and memoirs on living Rhizopods and lists of all the species they describe, together with the synonymy so far as giving the names of the same adopted by him.

2. *Zoology for Students and General Readers;* by A. S. Packard, Jr. 8vo, 719 pp. 544 cuts. New York: 1879. (Henry Holt & Co.)—This work is one of the best of the various manuals of Zoology that have recently appeared, and is decidedly better adapted for use in the class-room and laboratory than most of them. The general treatment of the subject is good, and the descriptions of structure and the definitions of groups are for the most part clear, concise, and not so much overburdened by technical terms as in several other manuals of structural Zoology now in use. The present work is largely devoted to structural or morphological Zoology, with pretty full accounts of the embryology of the various groups. Somewhat detailed accounts of the anatomy of various common representatives of the more prominent groups, both of vertebrates and invertebrates, add much to the value of the work for laboratory instruction. These are illustrated by good, original figures, showing the more prominent anatomical features. The dissections of vertebrates, and the figures illustrating them, are by Dr. C. S. Minot. The illustrations are throughout copious, and generally good and well-selected, though mostly borrowed from other works.

The classification adopted is, for the most part, nearly in accordance with the more recent European writers, and not very different from that of Huxley's recent works. One feature, that of dividing the "Crustacea" into two great groups, *Neocarida* and *Palæocarida*, is of very doubtful utility. If such a division be necessary it would seem better to adopt the name Crustacea for the former group, as has been done by others who have proposed the same division (under the name *Merostomata*), and to have given a new name (if any be needed where several are in use) only to the group cut off from the Crustacea. But it is doubtful whether

ie *Palæocarida*, including, as it does, Trilobites and Limuloids, in be maintained, with our present knowledge of the former, as a itural group, while it has been fully shown by the anatomical searches of A. Milne Edwards and others that *Limulus* is not a rustacean, in any proper sense. The *Pycnogonida* have also een badly treated, for this group, remarkable for so many iatomical and morphological peculiarities is dismissed in three nes (p. 360), as a family of *mites!* But the *Pycnogonida* would ot, by any means, go under the definition of the sub-class *Arachida*, much less into the order *Acarina*, for many of them have larger number of limbs than any true *Arachnida*. The dilation id relaxation of the limits and definitions of Insecta so as to iclude, not only the Arachnida, and Pycnogonida, but also *Periatus*, seem to us objectionable. The introduction of Mollusca etween the Vermes (including *Annelida*) and the Arthropoda oes injustice to the exceedingly close relationship existing beveen the Annelida and lower forms of Crustacea and Insecta; ut others have done so before. In the present unsettled condion of zoological classification, it would be useless, however, to y much stress upon the particular views adopted by any writer, ir these views are continually changing, as discovery advances.

A few errors, mostly of no great importance, we have noted. oubtless the author will, at an early date, have an opportunity correct them in a second edition. A few of the figures are inorrectly named: thus, fig. 74 represents *Asterias Forbesii* (not *l. vulgaris*); fig. 225, is *Palæmonetes vulgaris* (not *Crangon ulgaris*). On page 60, *Sarsia prolifera* is mentioned as "the only xample known of budding in free medusæ," the author evidently irgetting several New England species that are well known to have iis peculiarity in a marked degree and have long ago been so escribed in the works of L. Agassiz, A. Agassiz, and others. *Tybocodon prolifer* Ag., and *Dysmorphosa fulgurans* are notable xamples. The statement on p. 390 that "the products of digeson do not pass through the walls of the stomach and directly iter the circulation, as in invertebrates," is an obvious error, unss profoundly modified, by putting a small part for the whole. here appears to be some confusion on pp. 418 and 420 in referice to the breeding of the "dogfish," for on the former page it said that they lay eggs, while on the latter page "the dog-fish *Squalus Americanus*)" is mentioned. The latter produces living oung, as well as the *Mustelus canis*. A. E. V.

3. *Das System der Medusen* (*Erste Hälfte des ersten Theils: ystem der Craspedoten*); von Dr. ERNST HÆCKEL. i–x and 30 pp., with 20 plates. Jena, 1879.—Since the publication of schscholtz's System der Akalephen, an immense number of addions to our knowledge of some of the smaller groups of Medusæ ave been made. The principal attempts to revise the classificaon of the group as a whole we owe to Gegenbaur (1856) and gassiz (1862). Their own observations were based either upon uropean or American species, and they could do but little toward

clearing up the relationship of the many Acalephs described by older writers in the great voyages of circumnavigation of the earlier part of this century. Up to the time of Gegenbaur and Agassiz a great number of young forms of free Medusæ had been described, either as new genera or new species entirely independently of the study of the Hydroids and of their developmental history. It is easy to see that endless confusion must little by little have crept into the classification of the group. To reëstablish under these circumstances a certain amount of order in the classification of Acalephs, an investigator was demanded thoroughly familiar with the Acalephs of several districts in their living condition. Agassiz and Gegenbaur, though often holding very dissimilar views, have greatly simplified the classification of Medusæ, but no one has taken up the general subject since their time, and innumerable papers on special points of classification, anatomy and embryology have been published. Hæckel's System der Medusen, of which the first part is issued, is intended to incorporate all this material. With his extensive knowledge of Acalephs obtained during frequent visits to different points of the seashore, he proposes to revise the whole group, adding to the species already determined a great number of new species, nearly all of which are very effectively illustrated.

It is very satisfactory to find this work of Hæckel's free from the abusive personalities which have disgraced so many of his more recent productions, and to find his investigations full of ingenious views, acute criticisms, and speculations based upon observations and not upon fanciful theories. This memoir will take its place beside his Monographs on Radiolaria, on Sponges, and on the development of Acalephs, which have given Hæckel so prominent a place among investigators.

It seems unfortunate that Hæckel's facility for coining new names should lead him to reject so frequently the established names of the higher sub-divisions whenever they do not have the identical limits he himself assigns to any group. This method carried to its logical conclusion will render the rejection of all accepted names which do not enter into the systematic or morphological views of an author, not only necessary but imperative. Hæckel has no patience with systematists who constantly replace old names and compel the writers of the present day not to ignore completely their predecessors. He accuses them of needlessly increasing the existing confusion. Yet he himself ignores as completely existing nomenclature, and in his zeal to adopt or coin names representing his individual views, introduces a far greater confusion. This extreme method is not limited with Hæckel to the higher groups, but extends systematically to families, subfamilies and even genera, so that it will hereafter often be extremely difficult to trace the history of a genus or species which Hæckel has removed from one place to another as arbitrarily as the very systematist whom he so often takes to task. The existing confusion which is so frequently his theme is indeed only increased by his own equally arbitrary proceedings.

We certainly do not seem to gain anything either in exactness or in our knowledge of the groups by having the Tubularians (in the widest sense) appear again as Anthomedusæ or the Campanularians as Leptomedusæ. Yet in the primary sub-divisions of the Craspedota the classification adopted by Hæckel is an advance upon previous ones. The position of the Trachynemidæ and Cuninæ has always been a doubtful one. Hæckel enters the field with a mass of new information, and the position he assigns these groups is well sustained by the evidence he advances. He has likewise from the great number of Geryonidæ he has himself examined, finally cleared up the chaos existing in regard to the relationship of the family, and the divisions he adopts are extremely satisfactory. The recent magnificent histological work of the Hertwigs, of Eimer and others has thrown a flood of light on the affinities of many of the primary groups of Medusæ, of which Hæckel has availed himself to the fullest extent.

It seems to us that Hæckel has needlessly increased the number of his families, sub-families, genera and sub-genera; this has been carried so far by him, that it appears almost like a satire on his own work, and we feel inclined to vary the question with which in a somewhat dramatic way he closes each one of his general chapters "und was ist bei den Anthomedusen eine bona species?" by another: and what is among Craspedota, a family, a sub-family, a genus or a sub-genus?

It is incredible that Hæckel with his great knowledge of Medusæ should so readily transfer merely from the drawings of others the young of species with which he is not familiar, either into genera with which they have absolutely nothing in common, or establish new genera for their reception. Hæckel also makes a number of imaginary corrections of others, evidently due to careless reading. I may mention among them the retaining of both the Laodiceidæ and Melicertidæ, by A. Agassiz and their relationship to the Polyorchidæ, and his complete success in restoring the former confusion existing among the Thaumantiadæ instead of clearing it up, his criticisms on Turris, on Obelia and Eucope which he himself disproves a few pages afterward by adopting the same method to separate those of his own genera!

It seems to have escaped Hæckel that already in 1863 A. Agassiz had called attention to the confusion existing in the family of Berenycidæ as adopted by Agassiz in his Contributions; to this Hæckel again refers in his system where he has figured and described a number of most beautiful forms of this interesting family. For some very exquisite and striking figures given by Hæckel I may call attention to the illustrations of the genera Sarsia, Dipurena, Tiara, Catablema; the figures of the Cladonemidæ, the Berenycidæ, Eucopidæ (Otorchis), the Geryonidæ and Narcomedusæ.

Among the Cladonemidæ the new genus Ctenaria is held by Hæckel to be the most closely allied of all Craspedota to the Ctenopheræ. At first sight this appears quite true, but if we

analyze more closely the combination of characters of the genus, none of which are new, as Hæckel himself states, we cannot help being convinced that Hæckel has exaggerated beyond measure the external resemblance, and that there is not in Ctenaria a single feature characteristic of the Ctenophoræ, while on the contrary every structural detail is met with in some other genus of the Tubularians (Anthomedusæ). The eight ribs of lasso cells of Ctenaria, similar to those of Ectopleura, certainly can not, in our present state of knowledge, be homologized in any way with the locomotive flappers of Ctenophoræ. Nor is the symmetrically forked chymiferous tube a ctenophoric feature; it is a character of other Cladonemidæ, and of Willia and other genera, where, however, the branching is not symmetrical. Nor is there anything in the genital organs, the stomach, or proboscis, which we do not find in other Tubularian genera, while we find nothing whatever like the above structures in any Ctenophore. And finally, if we imagine the pedunculated knobs of lasso cells, of Gemmaria and Pteronema to be scattered along the peduncles we have the tentacles of Ctenaria, and when they are reduced to knobs on the tentacle, we have the identical structure of many of the Sarsiadæ and the like. But as Hæckel's specimen was an alcoholic one it is as yet by no means clear that the tentacles of Ctenaria differed in any way from those of the other Cladonemidæ.

That the material still remaining for investigation is very great is well known to all who have had occasion to sail on tropical seas and to see the immense wealth of pelagic life float by; while Hæckel's work shows how much progress could be made in our knowledge of Acalephs by selecting a few properly placed stations where Medusæ could be studied advantageously. A. AG.

4. *List of Dredging Stations occupied by the United States Coast Survey Steamers "Corwin," "Bibb," "Hassler," and "Blake," from* 1867 *to* 1879*;* by BENJAMIN PIERCE and CARLILE P. PATTERSON, Superintendents of the Coast Survey. (Bulletin of the Museum of Comparative Zoology, at Harvard College, Cambridge, Mass. Vol. vi, No. 1), September, 1879.

5. *Ophiuridæ and Astrophytidæ of the Challenger Expedition;* by THEODORE LYMAN. Part II. (Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass., vol. vi, No. 2). December, 1879.

6. *The Cotton Worm;* Summary of its Natural History, with an account of its enemies and the best means of controlling it; being a report of progress of the work of the Commission; by CHAS. V. RILEY, M.A., Ph.D. Washington. 1880. (United States Entomological Commission. Bulletin No. 3.)

IV. ASTRONOMY.

1. *Catalogue of the Library of the U. S. Naval Observatory.* PART I. *Astronomical Bibliography;* by Prof. E. S. HOLDEN, 4to, 10 pp. Washington, 1879.—This is part of a proposed Catalogue of the very valuable library of the Naval Observatory. Professor Holden has, we understand, done excellent service in securing the completion and in arranging this library. The present bibliography is not strictly confined to the books now in the library, nor to the literature of observational Astronomy. It will be a very valuable help to those who have not, as well as to those who have, access thereto.

It seems to have been intended to cover the bibliography of "Astronomy, Geodesy, Optics and Mathematics." But just as only in exceptional cases it has gone beyond the limits of the Observatory Library, so has it only partially filled these three branches of science bordering on Astronomy. The author might have made his catalogue much more useful had he marked out a well defined field, however narrow, and then covered the whole of it.

The list of books here given lacks symmetry, and the selection is based upon some system we have not been able to discern, or else there was a want of that painstaking labor in its preparation which we had a right to expect in whatever comes from the Naval Observatory. That the list does not cover "Geodesy, Optics and Mathematics," will be seen by the simple mention of a few of the principal works a student in those branches must needs consult. Thus Todhunter's History of the *Theory of Attraction and the Figure of the Earth*, Glaisher's *Report to the British Association on Tables*, DeHaan's memoirs on *Logarithmic Tables*, Scudder's *Catalogue of Scientific Serials*, Dove's *Literatur der Optik*, The *Fortschritte der Physik*, The *Fortschritte der Mathematik*, are leading works in Geodesy, Optics and Mathematics, and yet are all left out. Though the work ought to have been better, it will be very useful as it is. H. A. N.

2. *Publications of the Cincinnati Observatory.* No. 5. 180 pp. 8vo. Cincinnati, 1879.—This number contains the results of the measurements made by the Director, Mr. Stone, and his assistants, Messrs. Howe and Egbert, between January, 1878, and September, 1879, upon 1054 double-stars. In accordance with a plan early adopted the stars measured have been principally in the southern hemisphere. The exceptions were mainly well known doubles measured for personal equation, and new doubles discovered by Mr. Burnham. Nearly 200 new doubles in all have been detected at the observatory.

3. *Catalogue of the mean declination of* 2018 *stars between* 0^h *to* 2^h *and* 12^h *to* 24^h *R. A., and* 10° *to* 70° *N. decl., for January* 1, 1875; by T. H. SAFFORD. 4°, Washington, 1879.—This Catalogue was prepared under direction of Lieut. Wheeler of the U. S.

Engineer Department primarily for use in the geographical surveys west of the 100th meridian. The area in the heavens covered, is nearly one-fourth of the celestial sphere, being that part that is of use in field work. The aim has been to determine with the utmost accuracy attainable the declinations, and the annual precessions and proper motions in declination, of these stars, and incidentally the corresponding elements in R. A. The logs. of a' b' c' and d' are given for each star. For the region covered, this must for some time to come be a standard catalogue for the principal stars.

4. *Annals of the Astronomical Observatory of Harvard College.* Vol. xi, part II. Cambridge, 1879. By E. C. PICKERING, Director.—This part is a continuation of Photometric Observations made in 1877–9 principally with the large equatorial. The leading objects observed were the satellites of the various planets, a few of the asteroids, and about a hundred unequal double stars.

Assuming an albedo for the satellites equal to that of their primaries, and of the asteroids equal to that of Mars, Prof. Pickering arrives at the following diameters of some of the smaller members of the solar system in English miles, a result of general interest.

Phobos	5·57^m	Dione	542^m	Titania	586^m	Vesta	319^m
Deimos	4·85	Rhea	745	Oberon	544	Antiope	51
Mimas	292	Titan	1406	Sat. Nept.	2260	Brunhild	20
Enceladus	370	Hyperion	193	Pallas	167	Eva	14
Tethys	570	Japetus	486	Juno	94	Menippe	12

Japetus varies with his position in his orbit, which naturally leads to the conclusion that his time of rotation on his axis equals the time of revolution in his orbit, as is true for our moon. The diameters computed from the maximum, mean and minimum brilliancy are 574, 486, and 307 miles.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The Smithsonian Institution; Journals of the Board of Regents, Reports of Committees, Statistics, etc.;* Edited by WILLIAM J. RHEES. 844 pp. 8vo. Washington, D. C.: 1879 (Smithsonian Miscellaneous Collections, 329).—This volume has been compiled in accordance with the instructions of the Board of Regents to the Secretary, to have prepared and to publish a history of the origin and progress of the Smithsonian Institution. It contains the Journal of Proceedings of the Board of Regents from its first meeting, September 13, 1846, to January 26, 1876, together with the reports of the Executive, Building, and Special Committees. It also includes eulogies on deceased members of the Board, and distinguished collaborators of the Institution; also, an account of the Bache Fund, the Tyndall trust, the Corcoran Gallery of Art, and various other similar matters.

2. *Erasmus Darwin;* by ERNST KRAUSE; translated from the German by W. S. Dallas, with a preliminary notice by CHARLES DARWIN. 216 pp. 8vo. New York, 1880. (D. Appleton and

Company).—The first half of this work contains a life of Dr. Darwin by his grandson, and the remainder is devoted to a discussion of his scientific works by Krause. The book will be read with appreciation by many, both in view of the interest which attaches to the general history of the Theory of Development, and because it shows how far the habits of thought of the older naturalist have descended to the grandson who has given his name to "Darwinism."

3. *Blowpipe Analysis;* by J. LANDAUER; authorized English Edition by JAMES TAYLOR and WILLIAM E. KAY, of Owens College, Manchester. 161 pp. 12mo. London, 1879. (Macmillan and Co.)—The original German work, of which this is an English translation, was written some four years since by Mr. J. Landauer. It follows the manual of Elderhorst in the arrangement, but differs from it and other works in that it is prepared from a chemical rather than an exclusively mineralogical point of view. The various means and methods of blowpipe analysis are fully and well described and arranged in convenient tables. It contains an extended description of the flame reactions of Bunsen, and, also, as introduced by Mr. Taylor, his own systematic course of analysis, and an account of the reactions with the aluminium plate of Ross. It will be found a useful and satisfactory hand-book by those desiring to become acquainted with the practical use of the blowpipe.

4. *American Journal of Mathematics, pure and applied.* Editor-in-chief, J. J. SYLVESTER; Associate Editor-in-charge, WILLIAM E. STORY; with the coöperation of SIMON NEWCOMB, H. A. NEWTON, H. A. ROWLAND. Published under the auspices of the Johns Hopkins University, Baltimore.—The following is the table of contents of the last number of this Journal:—

On the Geographical Problem of the Four Colors, (Plate II), by A. B. Kempe, B.A., (of London); Note on the Preceding Paper, by William E. Story; The Quaternion Formulæ for Quantification of Curves, Surfaces and Solids, and for Barycentres, by W. I. Stringham; On the Dynamics of a "Curved Ball," by Ormond Stone; Note on Determinants and Duadic Synthemes, by J. J. Sylvester; Tables of the Generating Functions and Groundforms for the Binary Quantics of the First Ten Orders, by J. J. Sylvester, assisted by F. Franklin; Note on the Projection of the General Locus of Space of four dimensions into space of three dimensions, by Thomas Craig; On the Motion of an Ellipsoid in a Fluid, by Thomas Craig; On Certain Ternary Cubic-Form Equations, chapter I, On the Resolution of Numbers into the sums or differences of Two Cubes, by J. J. Sylvester; A New Proof of the Theorem of Reciprocity, by Dr. Julius Petersen, (of Copenhagen); On a New Action of the Magnet on Electric Currents, by E. H. Hall. (This article is cited on pp. 200–205 of this Journal).

That a Journal of this character should be so well supported is honorable alike to American science and to the University under whose auspices it is published.

5. *Narrative of the Polaris.*—It is announced that Mr. Defrees, the Public Printer at Washington, will receive, until June first, orders for the new edition of the Narrative of the Polaris, at two dollars per copy. The money must be sent him with the order. This is the beautiful edition, of which extra copies

have been sold by authority of Congress at ten per cent above the cost of press work and paper.

6. *Bernhard von Cotta Fund.*—A request has been made to all the pupils and friends of Bernhard von Cotta, who died at Freiberg on September 14, 1879, to join in erecting a monument to his memory, and in establishing a fund which shall be called the "Bernhard von Cotta Stiftung." The memorial stone is to be erected at a suitable spot in Freiberg; the fund is intended for the assistance of indigent students at Freiberg, either to enable them to take part in geological excursions, or in more extended tours, or to facilitate their studies in other ways. The advantages arising from this fund are to be open to all worthy students, irrespective of nationality or creed.

Among the large number in America who have been friends or scholars of von Cotta there must be many who will take pleasure in responding to this appeal. The American members of the Committee are: Prof. G. J. Brush, New Haven, Ct.; Prof. F. Prime, Philadelphia; Prof. Raphael Pumpelly, Newport, R. I.; Dr. R. W. Raymond, New York.

7. *The Naturalist's Quarterly*, Vol. i, No. 1, January, 1880, Salem, Mass. (Naturalist Bureau).—A popular magazine devoted to Natural History in all its branches.

8. *A Geological Atlas of the United States and Canada.*—It is proposed by Professor C. H. Hitchcock, as the completion of a plan made some years since, to prepare a geological map of the United States. The support of those interested is called for in order to make it possible to carry through the undertaking. The responsibility of issuing the map has been accepted by Mr. Julius Bien, of New York (18 Park Place), on condition that a sufficient number of subscribers be obtained to cover the expense.

The base is the United States Centennial Map, revised and completed by order of Congress. It is to be 8x13 feet, and will be furnished with the geological colors, mounted on rollers, at $50, or in sixteen sheets at $45 per copy. An explanatory text will accompany the map.

9. *M. Dumas.* — "Nature" has published (Feb. 6) an extra number devoted entirely to an account of the life and work of M. Dumas, the eminent French chemist. The paper is prepared by Dr. Hofmann, of Berlin.

10. *Erratum.*—In the notice of Professor Cope's memoir, on page 155 of this volume, the number of species mentioned in the eighth line should be *thirty*-seven instead of seven.

Brain Work and Overwork; by Dr. H. C. Wood, Clinical Professor of Nervous Diseases in the University of Pennsylvania, etc. 126 pp., 12mo. Philadelphia, 1880. (Presley Blakiston.)

The Pathology of Mind; being the third edition of the second part of the "Physiology and Pathology of Mind," recast, enlarged and rewritten; by Henry Maudsley, M.D. 580 pp., 8vo. New York: 1880. (D. Appleton & Co.)

APPENDIX.

ART. XXXI. — *Principal Characters of American Jurassic Dinosaurs;* by Professor O. C. MARSH. Part III. With six plates.

IN the previous articles of this series, the writer has recorded the more important characters of several groups of Dinosaurs from the Jurassic deposits of the Rocky Mountain region.* In the present communication, some of the peculiar features in the structure of the *Stegosauria* are made known. This sub-order proves to be one of the most specialized of the known Dinosaurs, and differs widely from the other groups.

Stegosaurus, Marsh, 1877.

The type genus of this group (*Stegosaurus*) may be taken as the representative of the suborder. Among the characters which at present distinguish this genus from the other known groups of Dinosaurs are the following:

(1) All the bones of the skeleton are solid.

(2) The femur is without a third trochanter.

(3) The crest on the outer condyle of the femur, which in Birds separates the heads of the tibia and fibula, is rudimentary or wanting.

(4) The tibia is firmly coössified with the proximal tarsals.

(5) The fibula has its larger extremity below.

Various other important characters of the present group, which are shared in part by some aberrant Dinosaurs, will be given below.

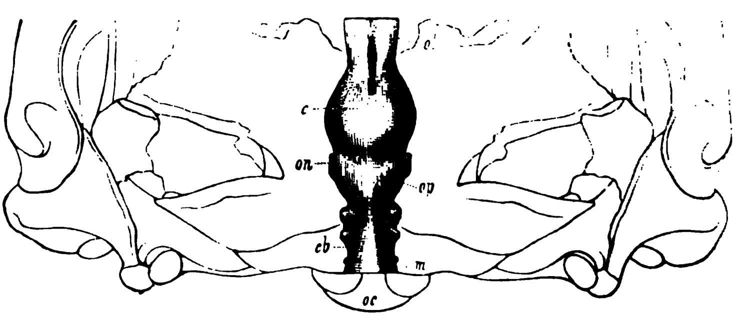
THE SKULL AND BRAIN.

The skull in the *Stegosauria*, so far as known, was remarkably small. In its main features it agreed more nearly with that of the genus *Hatteria*, from New Zealand, than with any other living reptile. The quadrates were fixed, and there was a quadrato-jugal arch. The jaws were short and massive.

* This Journal, xiv, 513; xv, 241; xvi, 411; xvii, 86; and xviii, 501.

Little has been known hitherto of the brain of Dinosaurs, but fortunately in one specimen of *Stegosaurus* the brain-case is well preserved, and apparently without distortion. Figures 1 and 2 of Plate VI show the form and general characters of this brain-cavity. The brain of this reptile was much elongated, and its most striking features were the large size of the optic lobes (*op*), and the small cerebral hemispheres (*c*). The latter had a transverse diameter only slightly in excess of the medulla. The cerebellum was quite small. The optic nerve (*on*) corresponded in size with the optic lobes. The olfactory lobes (*ol*) were of large size. As a whole, this brain was lacertilian rather than avian. A brain-cast of a young Alligator (figure 3) is given on the same plate for comparison. The contrast in the development of the cerebral region is marked, but in some other respects the correspondence is noteworthy.

In comparing the proportionate size of the brain of this living reptile with that of *Stegosaurus*, as given on Plate VII, the result proves of special interest. The absolute size of the two brain-casts is approximately as 1 to 10, while the bulk of the entire bodies, estimated from corresponding portions of each skeleton, was as 1 to 1000. It follows that the brain of *Stegosaurus* was only $\frac{1}{100}$ that of the Alligator, if the weight of the entire animal is brought into the comparison. If the cerebral regions of the two brains were alone compared, the contrast would be still more striking. This comparison, gives, of course, only approximate results, and some allowance should be made for the proportionally larger brain in small animals.



Outline of posterior part of skull and brain-cast of *Morosaurus grandis*, Marsh; superior view, one-fourth natural size; *ol.* olfactory lobes; *c.* cerebral hemispheres; *op.* optic lobes; *on.* optic nerve; *cb.* cerebellum; *m.* medulla; *oc.* occipital condyle.

The brain of *Stegosaurus ungulatus* is clearly of a lower type than that of *Morosaurus*, which, as the writer has shown, was several times smaller in diameter than the neural canal in its

own sacrum.* In the latter genus, the brain was proportionally shorter, and the cerebral region better developed, as shown in the cut above. The absolute size of this brain as compared with that of *Stegosaurus* is about 16 to 10, the brain of the Alligator figured being regarded as 1. Taking again the body of the Alligator as the unit, and *Stegosaurus* as 1000, that of *Morosaurus* would be about 1500. *Stegosaurus* had thus the smallest brain of any known land vertebrate. These facts agree fully with the general law of brain-growth, made out by the writer in extinct mammals and birds.

The Teeth.

The teeth of *Stegosaurus* are very numerous, and mostly cylindrical in form. Those from the maxillary figured on plate VI may be regarded as typical. The series represented in figure 4 consists of functional teeth in position, although separated from the jaw. The crowns are more or less compressed transversely, and are covered with thin enamel. The fangs are long and slender, and the pulp cavity is continued nearly or quite to the crown. The jaws contain but a single row of teeth in actual use. These are rapidly replaced as they wear out by a series of successional teeth, more numerous than hitherto observed in these reptiles. Figure 5, on Plate VI, represents a transverse section through the maxillary, immediately behind the fourth tooth. The latter is shown in place (1), and below it is a series of five immature teeth (2 to 6), in various stages of development, preparing to take its place. These successional teeth are lodged in a large cavity (*c*), which extends through the whole dental portion of the maxillary. The teeth in use were loosely implanted in separate sockets, and were readily displaced. The entire dental series evidently formed a very weak dentition, adapted to a herbivorous life.

The Vertebræ.

The vertebræ of *Stegosaurus* preserved all have the articular faces of their centra concave, although in some the depression is slight. They are all, moreover, without pneumatic or medullary cavities. On Plate VII, a selection from the vertebral series of one skeleton is given, which shows the principal forms. Figures 1 and 2 represent a median cervical. The other neck vertebræ have their centra of similar length, but the diameter increases from the axis to the last of the series. Some of the anterior cervicals have a small tubercle in the center of each end of the centra, a feature seen also in some of the caudals. All the cervicals supported short ribs.

* This Journal, vol. xvii, p. 87.

The dorsal vertebræ have their centra rather longer, and more or less compressed. The neural arch is especially elevated. The neural canal is much higher than wide. The head of the rib fits into a pit on the side of the neural arch. Figures 3 and 4, Plate VII, represent a posterior dorsal, with characteristic features. The ribs are massive, and strengthened by their form, which is T shaped in transverse section.

The sacral vertebræ are coössified, but their exact number in the present genus has not yet been fully determined.

The caudal vertebræ offer the greatest diversity, both in size and form. The anterior caudals are the largest in the whole vertebral series, and highly modified to support a portion of the massive dermal armour. The articular faces of their centra are nearly plane, and very rugose. The neural spine has an enormous development, and its summit is expanded into a bifurcate rugose head. These caudals are very short, and their neural spines nearly or quite in apposition above. These vertebræ have no distinct faces for chevrons. The transverse processes are expanded vertically, and their extremities curve downward. Further back, the same general characters are retained, but the centra are more deeply cupped, and the spines less massive. Figures 5 and 6, Plate VII, show a caudal vertebra from this region. The chevrons here have their articular ends separate, and rest upon two vertebræ. In the median caudals, the spine has greatly diminished in height, and the faces for chevrons are placed on prominent tubercles on the postero-inferior surface. The lower margin of the front articular face is sharp, and the chevrons do not meet it. In the more distal caudals (figures 7 and 8), the neural spine and zygapophyses are reduced to mere remnants, but the chevron facets remain distinct. These vertebræ, as well as those further back, have their centra much compressed. The caudal vertebræ are remarkably uniform in length throughout most of the series.

The Fore Limbs.

On Plate VIII, some of the bones of the scapular arch and anterior limbs of *Stegosaurus* are figured. The scapula and coracoid are of the true Dinosaurian type. The former has its upper portion rather short, and moderately expanded (figure 1). The coracoid was closely united to the scapula by cartilage. It is perforated by the usual foramen, which in some cases may become a notch.

The humerus (figure 2) is short and massive. It has a distinct head, and a strong radial crest. The shaft is constricted medially, and is without any medullary cavity. The ulna (figure 3) is also massive, and has a very large olecranal process. Its

distal end is comparatively small. The radius is smaller than the ulna. The fore limb, as a whole, was very powerful, and adapted to varied movements.

The Hind Limbs.

The pelvic arch of *Stegosaurus* is not complete in the specimens at present known, but its main characters agree with the Dinosaurian type. The acetabulum is formed by the ilium, ischium, and pubis. The last was apparently directed downward and forward. The ischium is shown on Plate IX, figure 1. It has a large head for union with the post-acetabular process of the ilium, and a thin extended vertical margin where it joins the pubis. At its distal end, it was united with its fellow by cartilage.

The femur of *Stegosaurus* (Plate IX, figure 2) is by far the largest bone in the skeleton. It is remarkably long and slender. There is no distinct head, and the great trochanter is nearly or quite obsolete. The shaft is of nearly uniform width, and very straight. There is no evidence of a third trochanter. The distal end of the femur is peculiar in having very flat condyles, with only a shallow depression between them. The external one has only a rudiment of the ridge which passes between the heads of the tibia and fibula, and is so characteristic of true Dinosaurs and Birds.

The tibia (figure 3) is very much shorter than the femur. Its superior end is unusually flat, indicating that it met the flat condyles of the femur so as to bring the two bones at times nearly or quite into the same line. The shaft of the tibia is constricted medially, leaving a wide space between it and the fibula. The distal end of the tibia is blended entirely with the convex astragalus, so as to strongly resemble the corresponding part in Birds.

The fibula (figure 3) is slender, and has its smaller end above. This extremity is applied closely to the head of the tibia by a rugose suture, so as readily to unite with it. Its upper articular surface is nearly or quite on a level with that of the tibia. The distal end of the fibula is expanded, and in the specimen figured is firmly coössified with the calcaneum. The two coalesce with the tibia and astragalus, and form a smooth convex articulation for the distal tarsals. The latter are distinct. The posterior limbs were more than twice as long as those in front.

The bones of the feet of *Stegosaurus* have not yet been fully identified, although a number have been found. In figure 4, Plate IX, a metapodial bone is shown, and in figure 4, Plate VIII, are views of a very characteristic terminal phalanx.

Dermal Spines and Plates.

The most remarkable feature about *Stegosaurus* is the series of ossifications which formed its offensive and defensive armour. These consist of numerous spines, some of great size and power, and many bony plates, of various sizes and shapes, well fitted for protecting the animal against assaults. Some of these plates are a meter, or more than three feet, in diameter.

The spines were of different forms, and varied much in size. On Plate X, four of these are represented. All of those preserved are unsymmetrical, and most of them are in pairs. One of the largest is shown in figure 1, which gives the more usual form and proportions. This specimen is over two feet (630 mm) in length, and its fellow is of the same size.

This spine has a rugose oblique base, and its sides are marked by vascular impressions and grooves similar to those on the bony horn-cores of ungulate mammals. It was evidently covered by a horny substance, and in life formed a most powerful weapon. The spinous appendage represented in figure 2 of the same plate was very similar in form and proportions, but of smaller size. It agrees closely with its mate, found not far from it. Nine different spines of this character were recovered with this same skeleton, and others may have been lost.

Figure 3 represents a different kind of spine. This also is obliquely truncated at the base, and thus is unsymmetrical, but its fellow has not been discovered. Its sides are flat and covered with vascular markings. There is a distinct ridge near the base, showing the depth this spine was inserted in the flesh. A smaller spine of the same general character was found near it. The small tubercular bone, shown in figure 1, Plate X, is very similar to the base of a spine-core, with the blade aborted.

The position these various spines occupied in life is uncertain, as none of them were found in place with portions of the skeleton fitted to support them. A spine somewhat similar to that in figure 2 was found with the skeleton of *Omosaurus*, in England, and regarded by Owen as a carpal appendage.* *Stegosaurus* may have been so provided, but the number and variety of the spines found with one skeleton indicate that various other parts were equally well armed. There are no indications of the attachment of spines to the tarsal region.

The dermal plates which protected the same animal were much more numerous than the spines. Some of them were so large and peculiar that their position is indicated by the structure of the anterior caudal vertebræ, whose enormous neural spines were especially adapted to support them.

* Palæontographical Society, 1875.

The plate represented on Plate XI, figure 2, was perhaps a dermo-neural spine, which stood erect over the caudal vertebræ. This would imply a deep compressed tail, and of this there are various indications. Several other plates found near the caudals probably occupied a similar position.

The largest plates discovered are similar to the one represented in figure 3. These are unsymmetrical, and their surfaces indicate that their position was on the back, arranged on each side of the medial line. There may have been several of these rows. Some of the smaller plates were discoidal in form, and quite thin. That shown in figure 1, is one of the smallest recovered. With such protection as the plates and spines together afforded, *Stegosaurus* was doubtless more than a match for his larger brained cotemporaries.

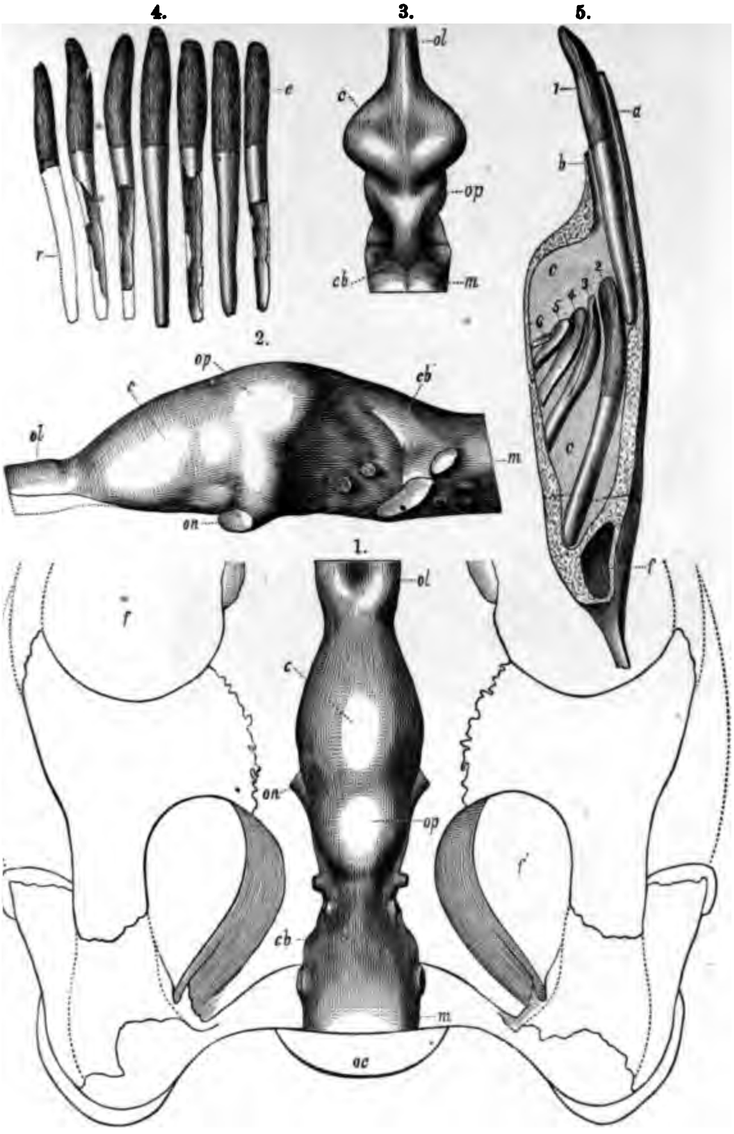
In considering the affinities of *Stegosaurus*, it would appear that the nearest known ally was *Omosaurus*. The fore limb, dorsal vertebræ, and one dermal spine are similar. The caudal vertebræ, however, are different, and there is no evidence that the latter genus was provided with plates, or that the skull and teeth were at all like those of *Stegosaurus*. They both may prove to belong in the same sub-order, and perhaps in the same family, *Stegosauridæ*.

The two known species of *Stegosaurus* were about thirty feet in length. They were herbivorous, and probably more or less aquatic in habit. It is possible that the difference between them was only sexual, as spines were found with only one.

The great disproportion in length between the fore and hind limbs, greater probably than in any known Dinosaur, would imply that *Stegosaurus* was more or less bipedal in its movements on land. The very short, powerful fore limbs, admitting of free motion, may have been well armed with spines, and thus used most effectively in defence. The back was evidently armed, as well as protected. When alive, *Stegosaurus* must have presented by far the strangest appearance of all the Dinosaurs yet discovered.

The remains of the animals here described are all from the Atlantosaurus beds of the Upper Jurassic, in Colorado and Wyoming. In bringing them to light, Messrs. Arthur Lakes, W. H. Reed, and S. W. Williston have rendered an important service to science.

Yale College, New Haven, Feb. 18, 1880.



igure 1.—Outline of skull and brain-cast of *Stegosaurus ungulatus*, Marsh; seen from above, one-half natural size; *ol*, olfactory lobes; *c*, cerebral hemispheres; *op*, optic lobes; *on*, optic nerve; *cb*, cerebellum; *m*, medulla; *f*, orbital cavity; *f'* temporal fossa; *oc*, occipital condyle.

igure 2.—Same brain-cast; side view, one-half natural size.

igure 3.—Brain-cast of young Alligator; three-fourths natural size.

igure 4.—Maxillary teeth of *Stegosaurus armatus*, Marsh; side view, one-half natural size; *e*, enamel; *r*, root.

igure 5.—Section of maxillary of *Stegosaurus armatus;* showing functional tooth in position, and five successional teeth in dental cavity; *a*, outer wall; *b*, inner wall; *c*, cavity; *f*, foramen.

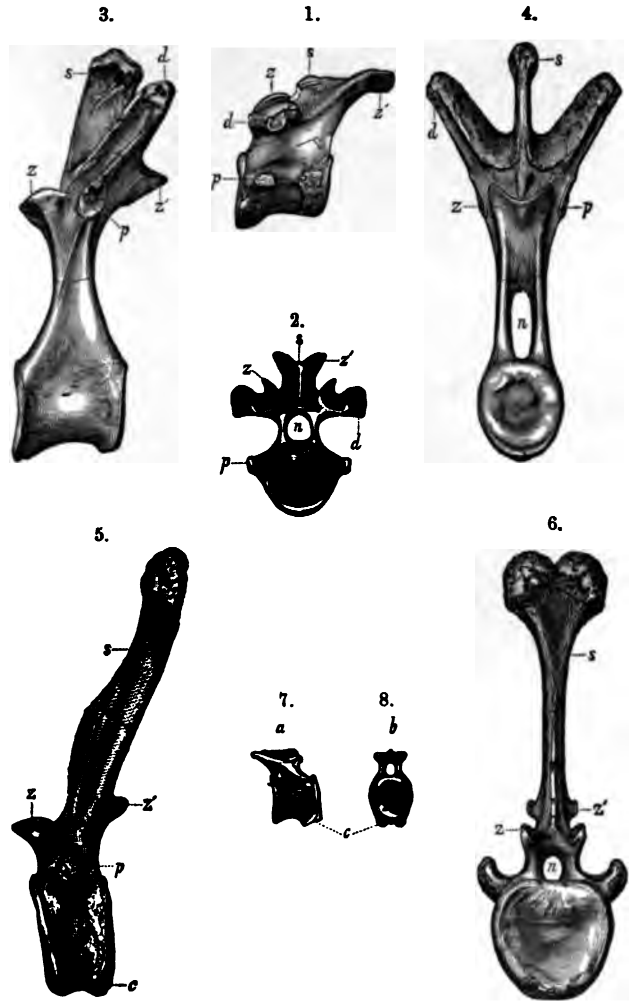
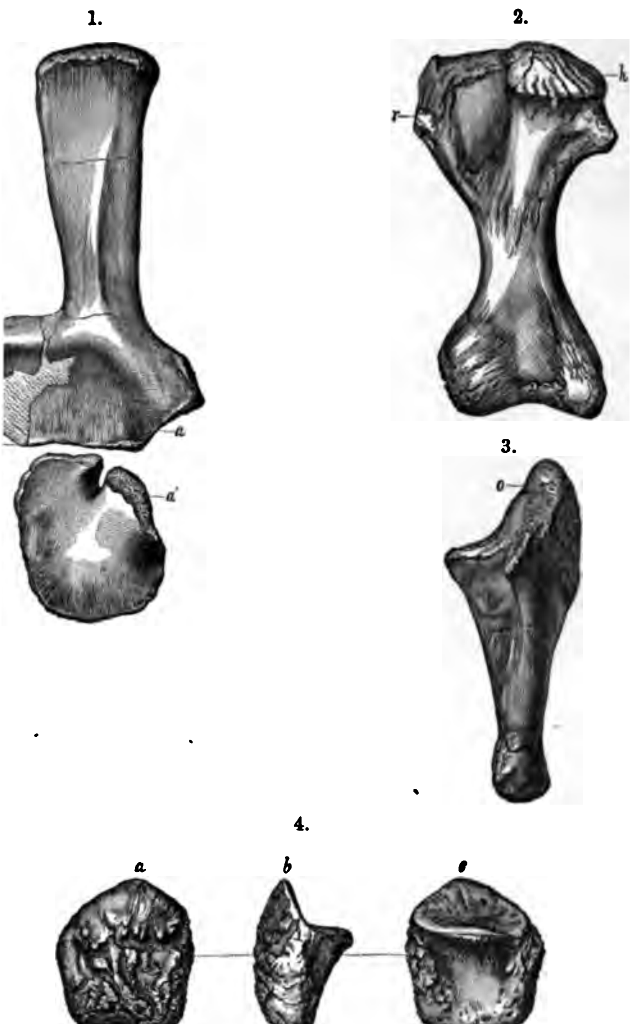


Figure 1.—Cervical vertebra of *Stegosaurus ungulatus*, Marsh; side view; *d*, diapophysis; *p*, parapophysis; *s*, neural spine; *z*, anterior zygapophysis; *z'*, posterior zygapophysis; *n*, neural canal.
Figure 2.—Same vertebra; front view.
Figure 3.—Dorsal vertebra of same series; side view; letters as above.
Figure 4.—Same vertebra; front view.
Figure 5.—Anterior caudal vertebra of same series; side view; *c*, face for chevron.
Figure 6.—Same vertebra; front view.
Figure 7.—Distal caudal of same series; side view.
Figure 8.—Same vertebra; front view.

All the figures are one-eighth natural size.



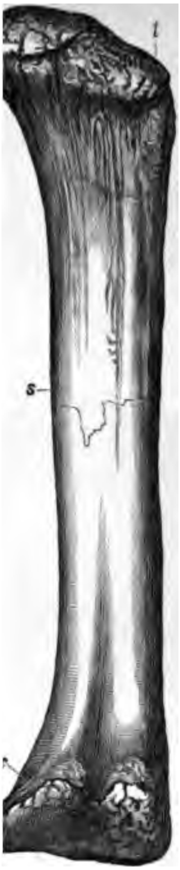
1.—Left scapula and coracoid of *Stegosaurus ungulatus*, Marsh; side ew, one-twelfth natural size; *a*, scapular face of glenoid cavity; *a'*, coraidean part of same; *b*, surface for union with coracoid.

2.—Humerus of *Stegosaurus ungulatus;* front view, one-twelfth natural ze; *h*, head; *r*, radial crest.

3.—Ulna of same; side view, one-twelfth natural size; *o*, olecranal ocess.

4.—Terminal phalanx of same species; one-fourth natural size; *a*, front ew; *b*, side view; *c*, posterior view.

2.



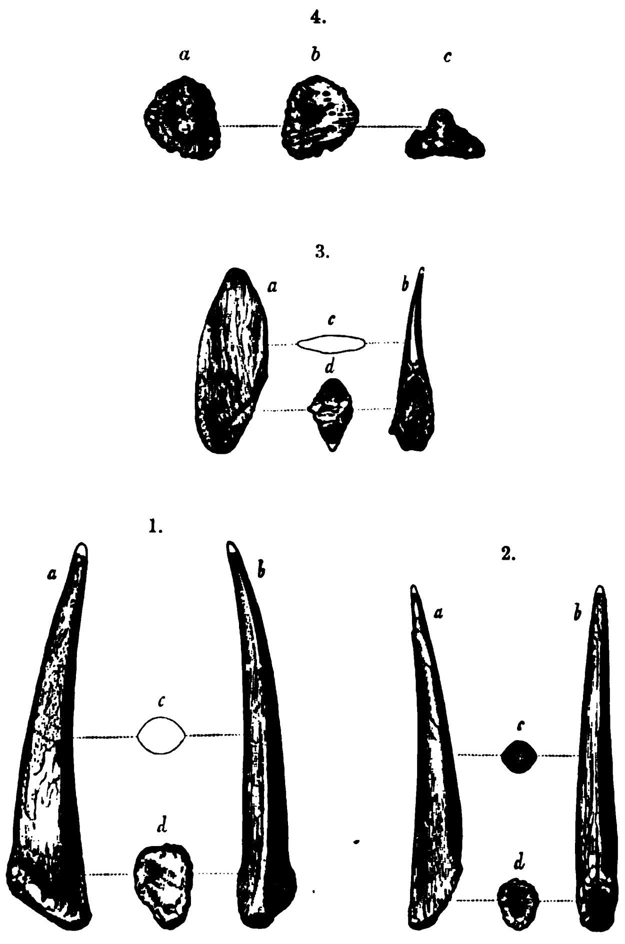
1.

3.

a b

4.

—Left ischium of *Stegosaurus ungulatus*, Marsh; side view, one-twelfth ral size; *a*, acetabulum; *i*, face for union with ilium; *p*, margin join-pubis; *s*, symphysis.
—Left femur of *Stegosaurus ungulatus*; front view, one-twelfth natural ; *t*, position of great trochanter; *s*, shaft, showing absence of third hanter; *c*, inner condyle.
.—Tibia and fibula of same limb; front view, same size; *a*, astragalus; lcaneum.
.—Metapodial bone of same animal; one-fourth natural size; *a*, side r; *b*, front view.



re 1.—Dermal spine of *Stegosaurus ungulatus*, Marsh; *a*. side view; *b*, front view; *c*. section; *d*. inferior view of base.
re 2.—Smaller dermal spine of same individual; *b*, posterior view; other letters as above.
re 3.—Flat dermal spine of same; letters as in figure 2.
re 4.—Tubercular spine of same species; *a*. superior view; *b*, inferior view: *c*, fore and aft view.

All the figures are one-twelfth natural size.

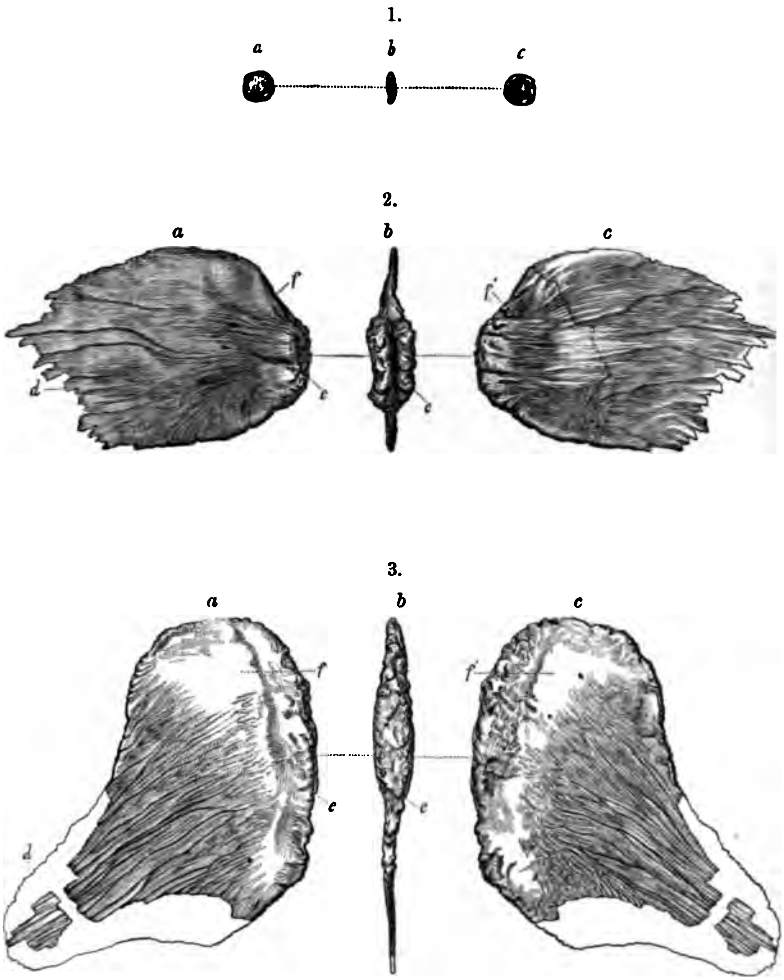


Figure 1.—Dermal plate of *Stegosaurus ungulatus*, Marsh; *a*, superior view; *b*, side view; *c*, inferior view.
Figure 2.—Dermal plate of same animal; *a*, side view; *b*, end view of base; *c*, view of opposite side; *d*, thin margin; *e*, rugose base; *f*, and *f'*, surface marked by vascular grooves.
Figure 3.—Dermal plate of same animal; *a*, superior surface; *b*, thick basal margin; *c*, inferior surface; other letters as in last figure.
All the figures are one-twelfth natural size.

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[THIRD SERIES.]

ART. XXXII.—*Notice of Berthelot's Thermo-Chemistry;* by J. P. COOKE, JR.

THE new work of M. Berthelot, entitled "Essai de Mécanique Chimique fondée sur la Thermo-chemie," presents for the first time in a systematic form the results accumulated during the past ten years from one of the most fruitful fields of investigation ever opened to the chemist. The book supplies a most important want, for the details of the work—published in numerous separate papers rapidly following each other in the chemical journals—have been almost unintelligible, except to those who have followed the investigation from the beginning, and no connected statement of the general principles involved was accessible to the student. The work in this new field has been done almost wholly by two investigators, Berthelot, of Paris, and Thomsen, of Copenhagen. Guided by different theoretical views, these skillful experimenters have gone over very nearly the same ground, and their united testimony, concurrent as it is in most cases, gives a certainty to the results obtained which is as fortunate as it is unusual when the field explored is so extensive as the one we are considering. These two men alone could write authoritatively on the subject, and it is, perhaps, fortunate that the first presentation should come from M. Berthelot, who has the usual skill of his nation in exposition and generalization.

In his introduction, Berthelot enunciates the fundamental principles of thermo-chemistry under the three following heads:

Principle of Molecular Work.

I. The quantity of heat evolved is the measure of the sum of the chemical and physical work accomplished in any reaction.

Principle of Conservation of Energy.

II. When a system of bodies—simple or compound—starting from a given condition undergoes either physical or chemical changes, which bring it into a new condition without producing any mechanical effect on external bodies, the amount of heat evolved or absorbed—as the total result of these changes—depends solely on the initial and final states of the system, and is the same, whatever may be the nature or order of the intermediate states.

Principle of Maximum Work.

III. In any chemical reaction between a system of bodies not acted on by external forces, the tendency is toward that condition and those products which will result in the greatest evolution of heat.

The first two of these principles are direct deductions from the mechanical theory of heat; but the third is a generalization, which Berthelot claims as original, and, if so, it is his greatest contribution to this department of the science. In the work before us the two first principles are discussed in the first volume, and this discussion, together with a description of the methods of experimenting and an enumeration of the numerical data thus far obtained, fill nearly 600 large octavo pages; while the discussion of the third principle occupies a second volume which is still larger. We will follow the same order in the few remarks which the limits of a short notice permit.

As the announcement of an almost axiomatic principle of thermo-dynamics, which every investigation of thermo-chemistry necessarily assumes, the first of these general principles has an appropriate place at the opening of a discussion of the subject. In regard to heat, as in regard to other manifestations of energy, the total effect is equal to the sum of all the partial effects. But Berthelot adds to his statement of the Principle of Molecular Work the remark—"This principle furnishes the measure of chemical affinities." When, however, we come to his discussion of this general principle, we are disappointed to find that the whole subject is summarily dismissed without giving the reader any clear conception of the distinction between the two modes of change whose results are so inextricably blended in all chemical processes.

Were we able to distinguish between chemical and physical change, the first principle would undoubtedly give us a measure of what we might then clearly define as chemical affinity or

chemism. Not only, however, is it, at present, impossible to eliminate from our results the effects of physical changes; but, moreover, when we study the details of the chemical processes with which we are most familiar, we are surprised to find to what a large extent the thermal effect depends on the changes in the obviously physical condition which the process involves. For example, in the formation of hydrogen gas from diluted sulphuric acid and zinc, the passing of a solid into a liquid, on the one hand, and the development of a gas from a liquid, on the other, involve physical changes which very largely control the amount of heat developed in the process, and, therefore, also according to the third principle, control the process. Indeed, as is well known, all chemical action ceases as soon as the water becomes saturated with zinc sulphate, although a large excess, both of sulphuric acid and of zinc, may be present. But, after making all allowances for the potency of physical conditions, it would undoubtedly appear from the present standpoint of Chemistry that there must be certain differences of qualities inherent in the atoms, which correspond to differences of chemical affinity and which are important factors in determining chemical changes, and it is certainly legitimate to seek to measure what we may call the relative potential of the atoms when in a state of indefinite expansion. It is obvious, however, from Berthelot's discussion of the subject, that we are, as yet, far from realizing such a result. In fact, the only case in which he claims that we measure directly the heat of chemical action independently of physical changes is in the well-known reaction $H_2+Cl_2=2HCl$, which is attended with the evolution of 22 units of heat for every 36·5 grams of hydrochloric acid gas formed. Since in this case the volume of the æriform compound is equal to the sum of the volumes of the two elementary gases from which the compound has been formed, and since, moreover, there has been no essential change in the specific heat, we may reasonably infer that the heat evolved results from chemical action only. But, according to the theory which is accepted by the great majority of chemists, this chemical action is by no means so simple as the direct union of two gas volumes would seem to indicate; for, as our symbols show, the process implies the parting of the similar atoms which are united in the molecules, both of hydrogen and of chlorine gases; and, unless we misinterpret a very large number of facts, this separation implies the expenditure of a no inconsiderable amount of mechanical work, and may imply a change of physical condition as well. Berthelot, in common with a school of French chemists, rejects the modern theory based on the assumption of the equal molecular volumes of all substances when in the state of gas, and uses throughout his

work the chemical equivalents of the older chemistry in place of the atomic weights of the new. At the same time he accepts fully the mechanical theory of heat and the conceptions of molecular work which this theory implies. To those who consider that Avogadro's Law, and, therefore, the modern theory of chemistry are direct deductions from the mechanical theory of heat, this course seems inconsistent, and this inconsistency deprives the work of a very considerable degree of simplicity which might otherwise have been secured. The remarkable progress made in organic chemistry during the last twenty years has resulted almost wholly from the circumstance that the investigators have worked back from the elementary substances to the elementary atoms and discussed the various modes in which these atoms might be grouped in the molecules. In the same way in thermo-chemistry we shall find no satisfactory basis until we go back likewise to the atoms and discuss the thermal effects which attend their union or their separation. One generalization we can already make in regard to atomic work with a great degree of certainty;—that the union of atoms is attended with the evolution of heat and the parting of the same atoms in the same associations with an equal absorption of heat:—and it must be remembered that, as defined by modern chemistry, atoms are definite masses of matter, so that in enunciating this general principle we refer to a palpable effect as resulting from a well-defined process, entirely independently of the theoretical views we may have in regard to the nature of the chemical atoms or of the modes by which they are united and grouped together. The general principle just stated explains a great many facts of thermo-chemistry which are otherwise anomalous and obscure. It moreover gives us the basis for a clear theoretical distinction between a chemical and a physical process, the first consisting in the separation or union of atoms, the last in the separation or drawing together of molecules. It is true that the distinction here drawn is, as yet, theoretical; but the theory involved gives us a basis from which to work, and this is enough for the present. The problem of finding what we have called the thermal potential of the atoms is not more remote than many problems which have been successfully solved in organic synthesis, and it is in this direction, as it seems to us, that we can alone expect to reach a measure of chemical affinity. It may, indeed, be found that the problem cannot be solved and attempts to solve it may lead to results which will modify or supplant our present theories. It may appear that the difference between a chemical and a physical process is one of degree and not of kind; but, whatever the result may be, there can be no doubt that the investigation will lead to larger knowledge and clearer conceptions.

As it seems to us the principle of molecular work should be supplemented by the principle of atomic work, and it is certain that neither clearness of conception nor definiteness of statement has been gained by the obvious attempt to avoid the recognition of the modern theory of chemistry.

We readily accept Berthelot's second fundamental principle of thermo-chemistry when enunciated as above, because it so obviously falls under the general law of conservation of energy; but it is obvious that this principle could not have been assumed prior to its experimental verification, any more than could the principle of the conservation of mass, prior to the experiments of Lavoisier, and as Lavoisier worked out this last great principle with the balance, so Berthelot and Thomsen have demonstrated with the calorimeter the corresponding fundamental principle of thermo-chemistry, which must be regarded as a generalization from the results of their work. Moreover, although in cases of simple direct combination the principle under discussion is almost self-evident, and has been long admitted, yet, before the investigations of Berthelot and Thomsen, no chemist conceived of its application in the very complex and indirect reactions by which the greater part of the thermo-chemical data have been obtained. It must be remembered that very few processes of direct chemical combination fulfill the conditions which an accurate measure of the accompanying thermal change involves, and a vast amount of chemical knowledge and ingenuity has been shown in devising indirect methods by which the results could be reached. The general theory of these indirect methods may be stated thus: We arrange two systems of reactions, both of which begin with the same factors in the same conditions, and end with the same product in the same conditions. In one of these series of reactions there must be no process whose thermal result—if not already known—cannot be measured with the calorimeter. In the other series the chemical combination or decomposition, whose thermal effect we are investigating, enters as an unknown term, the effect of the other chemical changes involved being known or capable of measurement, as in the first series. It follows now, from the principle we are discussing, that if we subtract the sum of the quantities measured in the second series from the sum of those measured in the first series we shall have the value of the unknown quantity. An example will make the method more intelligible.

It is required to determine the heat evolved when aluminum combines with bromine to form Al_2Br_6, and in the following scheme we assume, as is usual in this subject, that the chemical symbols stand for a number of grams corresponding to the atomic weight, and that the amount of heat is expressed in

gram units. Two series of reactions may now be arranged so as to fulfill the conditions we have assumed—

First Series.

$K_6 + Br_6$ (gas) $+ Aq = (6KBr + Aq)$	570,000 units.
$Al_2 + Cl_6 = Al_2Cl_6$	321,800 units.
Al_2Cl_6 dissolved in $(6KBr + Aq)$	152,000 units.
	1,043,800 units.

Second Series.

$K_6 + Cl_6 + Aq = (6KCl + Aq)$	604,800 units.
$Al_2 + Br_6 = Al_2Br_6$	x units.
Al_2Br_6 dissolved in $(6KCl + Aq)$	173,800 units.
	778,600 units.

$$x + 778{,}600 = 1{,}043{,}800. \quad x = 265{,}200.$$

In studying these two series of reactions it will be evident that we begin in each case with the same amounts of the same elementary substances, namely: K_6, Al_2, Br_6, Cl_6, and that we end with aqueous solutions in the same condition. Hence, the total amount of heat evolved in each of the two series must be the same, and we can at once deduce the value of the only unknown quantity. In this determination the only quantities which had to be measured at the time were the heat of solution of aluminic chloride in an aqueous solution of potassic bromide, on the one hand, and the heat of solution of aluminic bromide in an aqueous solution of potassic chloride, on the other, using, of course, equivalent quantities in each case. The other values given had previously been determined by indirect methods, and it can easily be seen that the investigation displays not only a great command of knowledge but also a great fertility of invention, and yet this is a comparatively simple case.

As deductions from the general principle of the conservation of energy, Berthelot gives a large number of theorems which serve to illustrate the extent and variety of its application to the study of the thermal changes which accompany chemical reactions. We give two as examples:

THEOREM III.—*In two series of reactions starting from different initial conditions, but ending in the same final state, the difference in the quantities of heat evolved is equal to that which would be evolved in passing from one of the initial states to the other.*

This theorem enables us to determine very simply the amount of heat evolved in the formation of the definite hydrates, although it would be very difficult if not impossible to form these substances with a definite composition in the calorimeter. Thus, to determine the heat evolved in the reaction $SO_3 + H_2O = H_2SO_4$, we have only to dissolve in one experiment SO_3 and in another H_2SO_4 in a comparatively large amount of

water when the difference in the heat evolved in the two cases will be the quantity required. So, also, the heat of formation of a hydrocarbon may be determined by comparing the heat of combustion of the compound with the heat of combustion of the hydrogen and carbon of which it consists. Thus the heat of combustion of acetylene C_2H_2 (26 grams) has been directly measured and is equal to 321,000 units, while the heat of combustion of C_2 (24 grams) plus the heat of combustion of H_2 (2 grams) only amounts to 257,000 units. Hence, it is evident that in the formation of 26 grams of acetylene 64,000 units are absorbed. Acetylene, indeed, belongs to a class of compounds whose formation is attended with the absorption of heat. This class of compounds which have a special interest in thermo-chemistry are said to be endothermous, while by far the larger class of compounds whose formation is attended with an evolution of heat are said to be exothermous.

THEOREM VI.—*When a compound gives up one of its elements to another body, the heat evolved in the reaction is the difference between the heat of formation of the first compound and that of the resulting product.*

Thus, when an aqueous solution of chlorine is used as an oxidizing agent, for every eighteen grams of water decomposed 9,600 units of heat are evolved, and this amount is the difference between the heat of formation of H_2O and 2HCl. As can easily be seen, the same theroem applies to the problem presented by explosive agents of various kinds and simplifies the solution to a remarkable extent.

These few illustrations will serve to give a general idea of the mode of investigation in this new field of thermo-chemistry, but they are wholly inadequate to show either the extent of the field or the great skill with which it has been cultivated. We must reserve for another number a notice of some very interesting relations which, under his third fundamental principle, Berthelot discusses in the second volume of his great work.

[To be continued.]

ART. XXXIII.—*The History of some Pre-Cambrian Rocks in America and Europe;* by T. STERRY HUNT, LL.D., F.R.S.

[Read before the American Association for the Advancement of Science at Saratoga, September 1, 1879.]

I. INTRODUCTION

ONE of the earliest distinctions in modern geology was that between the crystalline or so-called Primary strata, and those which are found in many cases to have been deposited upon them, and being in part made up of sediments derived from the disintegration of these, were designated Transition and Secondary rocks. While the past forty years have seen great progress in our knowledge of these younger rocks, and while their stratigraphy, the conditions of their deposition, and their geographical distribution and variations have been carefully investigated, the study of the older rocks has been comparatively neglected. This has been due in part to the inherent difficulties of the subject, arising from the general absence of organic remains, and from the highly disturbed condition of the older strata, but in a greater measure, perhaps, to certain theoretical views respecting the stratified crystalline rocks. In fact, the unlike teachings of two different and opposed schools lead to the common conclusion that the geognostical study of these rocks is unprofitable.

The first of these schools maintains that the rocks in question are, in great part at least, not subordinated to the same structural laws as the uncrystalline formations, but are portions of the original crust of the earth, and that their architecture is due not to aqueous deposition and subsequent mechanical movements, but rather to agencies at work in a cooling igneous mass. The igneous origin of gneisses, petrosilex-porphyries, diorites, serpentines, and even of magnetic and specular iron-ores was held and taught almost universally by our geologists, a generation since, and has still its avowed partisans; some maintaining that these various crystalline rocks are portions of the first-formed crust of the planet, while others imagine them to be volcanic matters extravasated at more recent dates; in either case, however, more or less modified by supposed metasomatic processes. By the term metasomatosis are conveniently designated those changes which are not simply internal (diagenesis), but are effected from without, as a result of which the chemical elements of the original rock are supposed to be either wholly or in part replaced by others from external sources (epigenesis).

The other school, to which allusion has been made, and which, not less than the preceding, has helped to discourage, in

the writer's opinion, the intelligent geognostical study of the crystalline stratiform rocks, is that which believes them to be, in great part at least, the result of chemical changes, often metasomatic in their nature, which have been effected in paleozoic and more recent sedimentary beds, obliterating their organic remains, and transforming them into crystalline strata. According to this view, feldspathic, hornblendic, and micaceous stratiform crystalline rocks, having similar mineralogical and lithological characters, may belong to widely separated geological periods; while the same geological series may, in one part of its distribution, consist of uncrystalline siliceous, calcareous, and argillaceous fossiliferous sediments, and in another locality, not far remote, be found, as the result of subsequent changes effected in these strata, transformed into gneiss, hornblende-schist or mica-schist, by what is vaguely designated as metamorphism.

The recent history of geology abounds in striking illustrations of the fact that in a great number of cases these views have been based on misconceptions in stratigraphy, and without entering into the discussion of the question, it may be said that, in the writer's opinion, careful stratigraphical study will, in all cases, suffice to show the error, both of the plutonic and the metamorphic hypothesis of the origin of crystalline rocks. The former is supported chiefly by the lithological resemblances between certain stratified and unstratified rocks, and by the appearances of stratification occasionally found in these; while the latter is sustained by the analogies offered in cases of local hydro-thermal action on sediments, and by the resemblances which recomposed materials frequently offer to their parent crystalline rocks. It is here maintained that the great formations of stratiform crystalline feldspathic, hornblendic and micaceous rocks, which, in various parts of the world, have been alternately described as plutonic masses, and as metamorphosed paleozoic, mesozoic or cenozoic strata are, in all cases, neptunean rocks, pre-Cambrian or pre-Silurian in age, and that we know of no uncrystalline sediments which are their stratigraphical equivalents.

We have then before us two schools, the one maintaining the secondary origin of a great, and, by them, undefined portion of the crystalline stratiform rocks, while assigning to certain older (pre-Cambrian) crystalline rocks (of which they admit the existence), either a neptunean or a plutonic origin. The other, or plutonist school, while asserting the plutonic derivation of the greater part of the crystalline formations, accepts, to some extent, also, the notion of secondary and neptunean metamorphic schists. It is believed that the above concise statements cover the ground held by the hitherto prevailing neptunean

and plutonist schools, neither of which, it is maintained, expresses correctly the present state of our knowledge. In opposition to both of these are the views taught for the last twenty years by the writer, and now accepted by many geologists, which may be thus defined:—

1st. All gneisses, petrosilexes, hornblendic and micaceous schists, olivines, serpentines, and in short, all silicated crystalline stratified rocks, are of neptunean origin, and are not primarily due to metamorphosis or to metasomatosis either of ordinary aqueous sediments or of volcanic materials.

2d. The chemical and mechanical conditions under which these rocks were deposited and crystallized, whether in shallow waters, or in abyssal depths (where pressure greatly influences chemical affinities) have not been reproduced to any great extent since the beginning of paleozoic time.

3d. The eruptive rocks, or at least a large part of them, are softened and displaced portions of these ancient neptunean rocks, of which they retain many of the mineralogical and lithological characters.

II. The History of Pre-Cambrian Rocks in America.

Coming now to the history of our knowledge of American crystalline rocks, we find that the lithological characters of the Primary gneissic formation of northern New York were known to Maclure in 1817, and were clearly defined in 1832, by Eaton, who, under the name of the Macomb Mountains, described what have since been called the Adirondacks, and moreover distinguished them from the Primary rocks of New England. Emmons, in 1842, added much to our lithological knowledge of the crystalline rocks of northern New York, but regarded the gneisses, with their associated limestones, serpentines and iron-ores, as all of plutonic origin. Nuttall, who had previously studied the similar rocks in the Highlands of southern New York and New Jersey, had, however, maintained, as early as 1822, that these had resulted from an alteration of the adjacent paleozoic graywackes and limestones, into which he supposed them to graduate. This view was, at the time, opposed by Vanuxem and Keating, but was again set forth in 1843, by Mather, who, while admitting the existence of an older or Primary series of crystalline rocks, conceived a great part of these rocks in southern New York to be altered paleozoic, and distinguished them as Metamorphic rocks. To this latter class he referred all the crystalline stratified rocks of New England, and ended by doubting whether a great part of what he had described as Primary was not to be included in his Metamorphic class. The subsequent labors of Kitchell and of Cooke

have however clearly established the views of Vanuxem and Keating as to the Primary age alike of the gneisses and the crystalline limestones of the Highlands.

The similar gneissic series in Canada, which was known to Bigsby and to Eaton as an extension of that of northern New York, was noticed by Murray in 1843, and by Logan in 1847, as pre-paleozoic, though apparently of sedimentary origin, and hence, according to them, entitled to be called Metamorphic rather than Primary. It was described by Logan in 1847, as consisting of a lower group of hornblendic gneisses, without limestones, and an upper group of similar gneisses, distinguished by interstratified crystalline limestones.

These rocks were found by Logan and by Murray to be overlaid both on Lake Superior and in the valley of the upper Ottawa by a series consisting of chloritic and epidotic schists, with bedded greenstones, and with conglomerates holding pebbles derived from the ancient gneiss below. The same overlying series had, as early as 1824, been described by Bigsby on Lake Superior, and by him distinguished from the Primary and classed with Transition rocks.

Labradoritic and hypersthenic rocks like those previously described by Emmons in the Primary region of northern New York, were, in 1853 and 1854, discovered and carefully studied in the Laurentide hills to the north of Montreal, when they were described as being gneissoid in structure, and as interstratified with true gneisses and with crystalline limestones. In 1854, the writer, in concert with Logan, proposed for the ancient crystalline rocks of the Laurentide Mountains, including the lower and upper gneissic groups already mentioned, and the succeeding labradoritic rocks (but excluding the chloritic and greenstone series), the name of Laurentian. In an essay by the writer, in 1855, the oldest gneisses of Scotland and of Scandinavia, were, on lithological and on stratigraphical grounds, referred to the Laurentian series, and at the same time the name of Huronian was proposed for the chloritic and greenstone series, which had been shown to overlie unconformably the Laurentian in Canada.

Previous to this, in 1851, Foster and Whitney had described the Laurentian and Huronian rocks of Lake Superior as constituting one Azoic system of Metamorphic rocks, with granites, porphyries and iron-ores, of igneous origin; and in 1857, Whitney attacked the two-fold division adopted by the Canadian geological survey, maintaining that the stratified crystalline rocks of the region belong to a single series, with a granitic nucleus. The observations of Kimball in 1865, and the later studies of Credner, of Brooks and Pumpelly, and of Irving, have, however, all confirmed the views of the Canadian survey

as to the relations of the Laurentian and Huronian in this region.

The Primary age of the Highlands of southern New York, and their extension in what is called the South Mountain, as far as the Schuylkill, was now unquestioned, but the crystalline rocks to the east of this range, while regarded by Eaton and by Emmons, as also forming a part of the Primary, were, by Mather, as we have already seen, supposed to be altered paleozoic strata. These rocks in New England, with the exception of the quartzites and limestones of the Taconic range, were by him assigned to a horizon above the Trenton limestone of the New York system, and portions of them were conjectured by other geologists, who adopted and extended the views of Mather, to be of Devonian age.

The characteristic crystalline schists of New England and southeastern New York, passing beneath the Mesozoic of New Jersey, re-appear in southeastern Pennsylvania, where they were studied and finally described by H. D. Rogers in 1858. According to him these crystalline schists, while resting unconformably upon an ancient (Hypozoic) gneissic system, were themselves more ancient than the Scolithus-sandstone, which he regarded as the equivalent of the Potsdam. While he supposed these newer crystalline schists, called by him Azoic, to be connected stratigraphically with the base of the Paleozoic series, he nevertheless assigned them to a position below the base of the New York system; thus recognizing in Pennsylvania, below this horizon, two unconformable groups of crystalline rocks, corresponding stratigraphically, as well as lithologically, with the Laurentian and the Huronian of the Lake Superior region.

The existence among these newer crystalline schists of Pennsylvania, of a series distinct from the Huronian, and representing the White Mountain or Montalban rocks (the Philadelphia and Manhattan gneissic group), had not then been recognized. Rogers at this time taught the igneous origin of the magnetic iron-ores, the quartz veins, the serpentines and their associated greenstones in this region. The belief entertained by Rogers of an intimate connection between his upper or Azoic series and the Paleozoic, had its origin apparently in the fact of the existence in this region of still another and a newer crystalline series, the Lower Taconic of Emmons, or the Itacolumite group of Lieber, which I have designated Taconian, and propose to consider in detail in a future paper. In it are included the iron-ores of Reading, Cornwall and Dillsburg, in Pennsylvania.

The views of H. D. Rogers with regard to the crystalline schists of the Atlantic belt were thus, in effect, if not in terms, a return to those held by Eaton and by Emmons, but were in direct opposition to that maintained by Mather, which had been

adopted by Logan, and by the present writer. The belt of micaceous, chloritic, talcose and epidotic schists, with greenstones and serpentines, the extension of a part of the Azoic of Rogers, which, through western New England, is traced into Canada (where it has been known as the Green Mountain range), was previous to 1862, called by the geological survey of Canada, Altered Hudson-River group. It was subsequently referred to the Upper Taconic of Emmons, to which Logan, at that date, gave the name of the Quebec group, assigning it, as had long before been done by Emmons (in 1846) to a horizon between the Potsdam and the Trenton of the New York system.

In 1862 and 1863 appeared, independently, two important papers bearing on the question before us as to the age of these rocks. The first of these, was by Thomas Macfarlane, who, after a personal examination of the three regions, compared the Huronian of Lake Huron and the Green Mountain range of Canada, with portions of the Urschiefer or Primitive schists which, in Norway, intervene between the ancient gneisses and the oldest Paleozoic (Lower Cambrian) strata. The second paper was by Bigsby, who was, as we have seen, the earliest student of the Huronian in the northwest, pointing out that these rocks could not in any sense be called Cambrian, but were the equivalents of the Norwegian Urschiefer. The conclusions of Macfarlane were noticed in connection with the views of Keilhau on these rocks of Norway in "The Geology of Canada" in 1863, with farther comparisons between the New England crystalline schists and the Huronian, but official reasons then, and for some years after, prevented the writer from expressing any dissent from the views of the director of the geological survey of Canada.

Meanwhile, the existence of an equivalent series of crystalline schists was being made known in southern New Brunswick, where they were described by G. F. Matthews in 1863, under the name of the Coldbrook group, which included a lower and an upper division. In a joint report of Matthews and Bailey in 1865, these rocks were declared to be overlaid unconformably by the slates in which Hartt had made known a Lower Cambrian (Menevian) fauna, and were compared with the Huronian of Canada. The lower division of the Coldbrook was then described as including a large amount of pink feldspathic quartzite and of bluish and reddish porphyritic slates. In the same report was described, under the name of the Bloomsbury group, a series lithologically similar to the Coldbrook, but apparently resting on the Menevian, and overlaid by fossiliferous Upper Devonian beds, into which it was supposed to graduate. The Bloomsbury group was therefore regarded as altered Upper Devonian, and its similarity to the pre-Cambrian Cold-

brook was explained by supposing both groups to consist in large part of volcanic rocks.

In 1869 and 1870, however, the writer, in company with the gentlemen just named, devoted many weeks to a careful study of these rocks in southern New Brunswick, when it was made apparent that the Bloomsbury group was but a repetition of the Coldbrook on the opposite side of a closely folded synclinal holding Menevian sediments. These two areas of pre-Cambrian rocks were accordingly described by Messrs. Matthews and Bailey in their report to the geological survey of Canada in 1871, as Huronian, in which were also included the similar crystalline rocks belonging to two other areas, which had been previously described by the same observers under the names of the Kingston and Coastal groups, and by them regarded as respectively altered Silurian and Devonian.

After studying the Huronian rocks in southern New Brunswick, and their continuation along the eastern coast of New England, especially in Massachusetts (where, also, they are overlaid by Menevian sediments), the writer in 1870, announced his conclusion that the crystalline schists of these regions are lithologically and stratigraphically equivalent to those of the Green Mountain range of western New England and eastern Canada. These, he further declared, in 1871, to be a prolongation of the newer crystalline or Azoic schists of Rogers in Pennsylvania, and the equivalents of the Huronian of the northwest. The pre-Cambrian age of these crystalline schists in eastern Canada has now been clearly proved by the presence of their fragments in the fossiliferous Cambrian strata in many localities along the northwestern border of the Green Mountain belt, and farther by the recent stratigraphical studies of Selwyn, as announced by him in 1878.

In close association with these Huronian strata in eastern Massachusetts is found a great development of petrosilex rocks, generally either jaspery or porphyritic in character, and sometimes fissile, which, by Edward Hitchcock were regarded as igneous. These were found to be identical with the rocks designated by Matthews and Bailey, feldspathic quartzites and siliceous and porphyritic slates, which form the chief part of the Lower Coldbrook or inferior division of the Huronian series in New Brunswick. The petrosilexes of Massachusetts were, after careful examination by the writer, described by him in 1870, and in 1871, as indigenous stratified rocks forming a part of the Huronian series. He subsequently, in 1871, studied the similar rocks in southeastern Missouri, and, in 1872, on the north shore of Lake Superior, but was unable to find them in the Green Mountain belt, or in its southward continuation, until, in 1875, he detected them occupying a considerable area

in the South Mountain range in southern Pennsylvania. The stratified petrosilex rocks of all these regions were described in a communication to this Association, in 1876, as apparently corresponding to the *hälleflinta* rocks of Sweden, and, having in view their stratigraphical position both in that country and in New Brunswick, they were then "provisionally referred" "to a position near the base of the Huronian series." Their absence in the Huronian belt in western New England, and in the province of Quebec, as well as at several observed points of contact between the Laurentian and the well-defined Huronian in the northwest, led to the suspicion that these hälleflintas might belong to an intermediate series.

C. H. Hitchcock has pointed out that the characteristic Huronian rocks do not form the higher parts of the Green Mountain range in Vermont, which he conceives to belong to an older gneissic series, a conclusion which the writer regards as premature. Hitchcock, however, in his final report on the geology of New Hampshire, in 1877, adopts the name of Huronian for the crystalline rocks of the Altered Quebec group of Logan, which makes up the chief part of the Green Mountain range in Quebec, is largely developed along it in Vermont, and appears in a parallel range farther east, which extends southward into New Hampshire. In his tabular view of the geognostical groups in this State, Hitchcock assigns to these rocks a thickness of over 12,000 feet, with the name of Upper Huronian; while he designates as Lower Huronian the petrosilex series of eastern Massachusetts, already noticed, where these rocks are of great, though undetermined, thickness. The similar petrosilex or hälleflinta rocks in Wisconsin, where they have lately been described by Irving as Huronian, have, according to this observer, a thickness in a single section, of 3,200 feet. They here sometimes become schistose, and are interbedded with unctuous schists, and rest in apparent conformity upon a great mass of quartzite. The general high inclination both of this series and of the typical Huronian, renders the determination of their thickness difficult. The maximum thickness of the Huronian (excluding the petrosilex series) to the south of Lake Superior, may, according to Major Brooks, exceed 12,000 feet, while the estimates of Credner and Murray, respectively, for this region, and for the north shore of Lake Huron, are 20,000 and 18,000 feet.

As regards the Laurentian, there exists a certain confusion of nomenclature which requires explanation. As originally described, it includes, as already said, a basal granitoid gneiss without limestones, which the writer has elsewhere designated the Ottawa gneiss, and of which the thickness is necessarily uncertain. Succeeding this is the Grenville series of Logan,

having for its base a great mass of crystalline limestone, and consisting in addition to this of gneisses, generally hornblendic, and quartzites, interstratified with similar limestones. To this series, as displayed north of the Ottawa, Logan assigned an aggregate thickness of over 17,000 feet, though the later measurements of Vennor, in the region south of the Ottawa, give to it a much greater volume. The geographical distribution of this limestone-bearing Grenville series gives probability to the suggestion of Vennor that it rests unconformably upon the basal Ottawa gneiss.

These two divisions constitute what was designated by Logan, in his Geological Atlas, in 1865, the Lower Laurentian, the name of Upper Laurentian or Labradorian being then, for the first time given by him to a series supposed to overlie unconformably the former, of which it had hitherto been regarded as constituting a part. This third division has already been referred to as characterized by the predominance of great bodies of gneissoid or granitoid rocks, composed chiefly of labradorite or related anorthic feldspars, and apparently identical with the norites of Scandinavia. With these basic rocks are interstratified crystalline limestones, quartzites and gneisses, all of which resemble those of the Grenville series. This upper group, for which the writer in 1871 proposed the name of Norian, was supposed by Logan to be not less than 10,000 feet thick.

For farther details of the history of these various groups of pre-Cambrian rocks, and their distribution in North America, the reader is referred to a volume published in 1878 by the Second Geological Survey of Pennsylvania, being Part I of the writer's report on Azoic Rocks, intended as an historical introduction to the subject.

III.—The History of Pre-Cambrian Rocks in Great Britain.

In an address before this Association in 1871, in which the writer maintained the Huronian age of a portion of the crystalline schists of New England and Quebec, he further expressed the opinion, based in part upon his examinations at Holyhead in 1867, and in part upon the study of collections in London, that certain crystalline schists in North Wales would be found to belong to the Huronian series. The rocks in question were by Sedgwick, in 1838, separated from the base of the Cambrian, as belonging to an older series, but were subsequently, by Delabeche, Murchison and Ramsay, described and mapped as altered Cambrian strata, with associated intrusive syenites and feldspar-porphyries.

In South Wales, at St. David's in Pembrokeshire, is another area of crystalline rocks, which the geological survey of Great

Britain had mapped as intrusive syenite, granite and felstone (petrosilex-porphyry) having Cambrian strata converted into crystalline schists on one side, and unaltered fossiliferous Cambrian beds on the other. So long ago as 1864, Messrs. Hicks and Salter were led to regard these granitoid and porphyritic rocks as pre-Cambrian, and in 1866 concluded that they were not eruptive but stratified crystalline or metamorphic rocks. After farther study, Hicks, in connection with Harkness, published in 1867, additional proofs of the bedded character of these ancient crystalline rocks, and in 1877 the first named observer announced the conclusion that they belong to two distinct and unconformable series. Of these, the older consisted of the granitoid and porphyritic felstone rocks, and the younger of greenish crystalline schists, the so-called Altered Cambrian of the official geologists; both of these being overlaid by the undoubted Lower Cambrian (Harlech and Menevian) of the region, which holds their ruins in its conglomerates. To the lower of these pre-Cambrian groups, Hicks gave the name of Dimetian, and to the upper that of Pebidian. The last, with a measured thickness of 8000 feet, he supposed to be the equivalent of the Huronian, and compared the Dimetian with the Upper Laurentian of Logan.

The similar crystalline rocks of North Wales, already noticed, were now studied by Professor T. McKenny Hughes of Cambridge, who described them in 1878. These include in Carnarvonshire and Anglesey the greenish crystalline schists which the writer in 1871 referred to the Huronian (pre-Cambrian of Sedgwick, and Altered Cambrian of the geological survey), certain granitoid rocks formerly described as intrusive syenite, and also a reddish feldspar-porphyry which forms two great ridges in Carnarvonshire. This latter was by Professor Sedgwick regarded as intrusive, and is moreover mapped as such by the geological survey, though described in Ramsay's memoir on the geology of North Wales as probably the result of an extreme metamorphism of the lower beds of the Cambrian. The pre-Cambrian age of all these rocks was clearly shown by Hughes, who however considered that the whole might belong to one great stratified series; while Hicks, from an examination of the same region, regarded them as identical with the Dimetian and Pebidian of South Wales.

Dr. Hicks continued his studies in both of these regions in 1878,—being at times accompanied by Dr. Torell of Sweden, Professor Hughes and Mr. Tawney of Cambridge, and the writer—and was led to conclude that beside the chloritic schists and greenstones (diorites) of the Pebidian, and the older granitoid and gneissic rocks, there exists, both in North and South Wales, a third independent and intermediate series,

to which belong the stratified petrosilex or quartziferous porphyries already noticed. These are sometimes wanting at the base of the Pebidian, and at other times form masses some thousands of feet in thickness. At one locality, near St. David's, a great body of breccia or conglomerate, consisting of fragments of the petrosilex united by a crystalline dioritic cement, forms the base of the Pebidian. For this intermediate series, which constitutes the great quartziferous-porphyry ridges of Carnarvonshire, Dr. Hicks and his friends proposed the name of Arvonian, from Arvonia, the Roman name of the region.

This important conclusion was announced by Dr. Hicks at the meeting of the British Association for the Advancement of Science at Dublin, in August, 1878. The writer, previous to attending this meeting, had the good fortune to examine these various pre-Cambrian rocks in parts of Carnarvonshire and Anglesey with Messrs. Hicks, Torell and Tawney. He subsequently, in company with Dr. Hicks, visited the region in South Wales where these older rocks had been studied, and was enabled to satisfy himself of the correctness both of the observations and conclusions of Dr. Hicks, and of the complete parallelism in stratigraphy and in mineral composition between these pre-Cambrian rocks on the two sides of the Atlantic. It may here be mentioned that Dr. Torell, who, during his visit to America in 1876, had an opportunity of studying, with the writer, the petrosilexes of New England and Pennsylvania, which he regarded as identical with the hälleflinta of Sweden, at once recognized them in the Arvonian series of North Wales.

Of the many areas of these various pre-Cambrian rocks which the writer was enabled to examine in company with Dr. Hicks, may be mentioned the granitoid mass of Twt Hill in the town of Carnarvon, and the succeeding Arvonian to Port Dinorwic, followed, across the Menai strait, by the Pebidian on the island of Anglesey, near the Menai bridge. Farther on, the Pebidian was again met with near the railway station of Ty Croes, in the southwest part of the island, succeeded by a large body of Arvonian petrosilex, and a ridge of granitoid gneiss, fragments of which make up a breccia at the base of the Arvonian series. The Pebidian is again well displayed at Holyhead.

In South Wales, the similar rocks were examined by him at St. David's, where three small bands of an impure coarsely crystalline limestone are included in the Dimetian granitoid rock, which is here often exceedingly quartzose. It may be remarked that the Dimetian, as originally defined at this, its first recognized locality, included a great mass of Arvonian

petrosilex, the two forming a ridge which extends for some miles in a northeast direction, flanked by Pebidian rocks, which are sometimes in contact with the one and sometimes with the other series. At Clegyr bridge was seen the base of the Pebidian, already mentioned as consisting of a conglomerate of Arvonian fragments. Another belt of the same crystalline rocks was also visited, a few miles to the eastward of the last, and not far from Haverfordwest, forming, according to Hicks, a ridge several miles in length and about a mile wide. Where seen, at Roch Castle, it was found to consist of Arvonian petrosilex, with some granitoid rock near by. The ridge is flanked on the northwest side by Pebidian and Cambrian, and on the southeast by Silurian strata, let down by a fault.

On the shore of Llyn Padarn, near the foot of Snowdon in North Wales, the porphyritic petrosilex of the Arvonian is again well displayed, while in contact with it, and at the base of the Llanberis (Lower Cambrian) slates, is a conglomerate made up almost wholly of the petrosilex. This locality was supposed by Prof. Ramsay and others to show that the petrosilex is the result of a metamorphosis of the lower portion of the Cambrian, the conglomerates being regarded as beds of passage. The writer, after a careful examination of the locality, agrees with Messrs. Hicks, Hughes and Bonney that there is no ground for such an opinion, but that the conglomerate marks the base of the Cambrian, which here reposes on Arvonian rocks, and is chiefly made up of their ruins. In like manner, according to Prof. Hughes, the Cambrian in other parts of this region includes beds made of the *débris* of adjacent granitoid rocks.

These petrosilex conglomerates of Llyn Padarn are indistinguishable from those found at Marblehead and other localities near Boston, Massachusetts, which have been in like manner interpreted as evidences of the secondary origin of the adjacent petrosilex beds, into which they have been supposed to graduate The writer has, however, always held, in opposition to this view, that these conglomerates are really newer rocks made up of the ruins of the ancient petrosilex. He has found similar petrosilex-conglomerates at various points on the Atlantic coast of New Brunswick, of Lower Cambrian, Silurian and Lower Carboniferous ages, all of which have, in their turn, been by others regarded as formed by the alteration of strata of these geological periods. The evidence now furnished in South Wales of still older (Huronian) beds of petrosilex-conglomerate should be noted by students of North American geology. From observations near Boston, made by one of my former students, I have for some time suspected the existence of petrosilex-conglomerates of pre-Cambrian age.

To the eastward of the localities already mentioned in Wales, are some other small areas of crystalline rocks, including those of the Malverns, and the Wrekin and other hills in Shropshire, all of which appear as islands among Cambrian strata; also those of Charnwood Forest, in Leicestershire, which rise in like manner among Triassic rocks. The Wrekin, regarded by Murchison as a post-Cambrian intrusion, has been shown by Callaway to be unconformably overlaid by Lower Cambrian strata, and consists in part of bedded greenstones, and in part of banded reddish petrosilex-porphyries, closely resembling the Arvonian of North Wales and the corresponding rocks of North America. The geology of Charnwood has within the past two years been carefully studied by Messrs. Hill and Bonney. The ancient rocks of this region are in part crystalline schists (embracing, in the opinion of Dr. Hicks and of the writer—who have seen collections of them—representatives both of the Pebidian and the Arvonian of Wales) and in part eruptive masses, including the granitic rocks of Mount Sorrel.

There is not, so far as known, in the British localities already mentioned, any representative either of the Taconic or Itacolumite group, or of the white micaceous gneisses, with micaceous and hornblendic schists, which I have designated the Montalban series. I have, however, found the latter well displayed in Ireland, in the Dublin and Wicklow Hills. The probable presence both of this series and of the Huronian in the northwest of Ireland was pointed out by me in 1871. I have there lately seen the Huronian on Lough Foyle, and also in Scotland in various parts of Argyleshire and Perthshire, as along the Crinan Canal and in the vicinity of Loch Etive and Loch Awe. From collections sent me by Mr. James Thomson, of Glasgow, it appears that both Huronian and Laurentian rocks occur in the island of Islay.

The crystalline schists of Charnwood offer, as was pointed out by Messrs. Hill and Bonney, many resemblances with parts of the Ardennian series of Dumont in France and Belgium. These, which have been in turn regarded as altered Devonian, Silurian and Lower Cambrian, were, as shown by Gosselet, islands of crystalline rock in the Devonian sea, and in one part include argillites with impressions of *Oldhamia* and an undetermined graptolite. These rocks have lately been described in detail in the admirable memoir of de la Vallée Poussin and Renard. The writer had the good fortune, in 1878, to visit this region, and in company with Gosselet and Renard to examine the section along the valley of the Meuse. The crystalline rocks here displayed greatly resemble those of the American Huronian, in which may be found most of the types described by the authors of the memoir just mentioned. It

would be easy to extend further this review of late advances made in the study of the ancient crystalline rocks, but the writer has preferred to confine himself to those regions which he has lately examined.

CONCLUSIONS.

1. The Pebidian of Hicks has both the lithological characters and the stratigraphical position of the Huronian of North America, to which he has already referred it.

2. The Arvonian is, in like manner, identical with the Hälleflinta group of Sweden and with the Petrosilex group of North America, which I had provisionally included in the lower part of the Huronian, and which Hitchcock subsequently called Lower Huronian. The fact that there is in Wales a stratigraphical break between it and the overlying Huronian, will help to explain the frequent absence of the Arvonian at the base of Huronian in many of its American localities.

3. The Dimetian, including the granitoid and gneissic rocks with limestone bands, so far as can be seen in the limited outcrops, is indistinguishable from parts of the Laurentian of North America. It was from a misconception that Dr. Hicks in 1878 provisionally referred the Dimetian to the Upper Laurentian, a name at one time used by the geological survey of Canada to designate the Norian series, which in some parts of North America overlies unconformably the Laurentian. Hicks at the same time designated as Lower Laurentian the gneiss of the Hebrides (Lewisian of Murchison), which he believed to be distinct from and older than the Dimetian. These two apparently correspond to the Ottawa and Grenville divisions of the proper Laurentian in Canada, and perhaps to the Bojian and Hercynian gneisses of Gümbel, in Bavaria.

[The following is a partial list of publications relating to the rocks noticed in part III of this paper:

In the Quar. Jour. Geol. Soc. of London are the following papers on these rocks in Wales: Hicks, May, 1877, p. 230; Hicks & Davies, Feb., 1878, p. 147, and May, 1878, p. 153; Hughes & Bonney, Feb., 1878, p. 137; Hicks & Davies, May, 1879, p. 285: Hicks & Bonney, ibid., p. 295; Bonney, ibid., p. 309; Bonney & Houghton, ibid., p. 321; Hughes, Nov., 1879, p. 682; Maw, Aug., 1878, p. 764; also Hicks, rocks of Ross-shire, Nov., 1878, p. 811. Tawney, Older Rocks of St. Davids: Proc. Bristol Naturalists' Society, vol. ii, part 2, p. 110.

On these rocks in Shropshire, in the same journal, Allport, Aug., 1877, p. 449; Callaway, Nov., 1877, p. 653, and Aug., 1878, p. 754; Callaway & Bonney, Nov., 1879, p. 643.

On these rocks in Charnwood Forest, in the same journal, Hill and Bonney, Nov., 1877, p. 753, and May, 1878, p. 199.

See farther, Hunt, Chemical and Geological Essays, pp. 34, 269, 270, 272, 278, 283; also his Azoic Rocks, part i (Second Geol. Survey of Penn., 1878), pp. 187, 188.

For the rocks of the Ardennes see Memoire sur les Roches dites Plutoniques, etc. (4to, pp. 264), by de la Vallée Poussin and Renard, from Memoires de la

l'Acad. Royale de la Belgique for 1876; and Memoire sur la Comp. Minéralogique du Coticule, by Renard, from the same for 1877. Also Gosselet and Malaise, Terrain Silurian des Ardennes, Bull. Acad. Roy. de la Belgique (2) No. 7, 1868; Dewalque, Terrain Cambrien des Ardennes, Ann. Soc. Géol. de la Belgique, tom. i, p. 63; and farther, Hunt, Chem. and Geol. Essays, p. 270.]

Appendix.

Since the above paper was read the author has received (November, 1879) a private communication from Prof. L. W. Bailey giving his latest results as to the pre-Cambrian rocks of southern New Brunswick, which confirm what has already been said about that region. Bailey separates the Huronian into a lower division, for which he reserves the name of Coldbrook, consisting chiefly of petrosilex rocks, and an upper division, the typical Huronian, called by him the Coastal group. He adds that there is between the two a marked physical break, which is indicated by a stratigraphical discordance, and by the presence in the lower part of the Coastal group of coarse conglomerates made up from the ruins of the Coldbrook or underlying division. This corresponds to the break between the similar Arvonian and Huronian in South Wales.

At the meeting of the British Association for the Advancement of Science at Sheffield in August, 1879, Dr. Hicks read a paper on the Classification of the British Pre-Cambrian Rocks, which is published in the Geological Magazine for October, 1879. He concludes that the Pebidian is "a group of enormous thickness, which is largely distributed over Great Britain, where it has a prevailing strike of N.N.E. and S.S.W., or from this to N.E. and S.W." In addition to the localities which we have already mentioned in Great Britain, he notes its occurrence in Shropshire and in Charnwood Forest, and also in the northwest of Scotland, where, as elsewhere, it enters largely into the Lower Cambrian conglomerates. The group is concisely described by him as consisting "for the most part of chloritic, talcose, feldspathic and micaceous schistose rocks, alternating with slaty and massive greenstones, dolomitic limestones, serpentines, lava-flows, porcellanites, breccias and conglomerates. It is also traversed frequently by dykes of granite, dolerite, etc."

The conglomerates at the base of the Huronian in Wales are largely made up of the masses derived from the Arvonian, with which it "is undoubtedly at most of the points examined, unconformable." This Arvonian series, Hicks regards as identical with the great Hälleflinta group of the Swedish geologists and with the Petrosilex series which the writer has made known in America. In addition to the localities already mentioned of it in the British Isles, Hicks notes its occurrence in

the Harlech Mountains and the Orkneys, and probably also in the Western Islands, and in the Grampians of Scotland. Its strike in the regions examined by him is generally about N. and S.

As regards the gneissic Dimetian group, the strike of which is N.W. and S.E., or from this to N. and S., Hicks adds to the localities in Wales, already noticed, its occurrence in the Malvern chain, especially in the Worcester Beacon, and cites Dr. Callaway as authority for its existence in Shropshire. Hicks further notes its presence at several points in the northwest Highlands of Scotland. From this series of light-colored gneisses, often very quartzose, with limestone bands, he separates, as we have seen, under the name of Lewisian, proposed by Murchison for the ancient gneisses of Lewis and others of the Hebrides Isles, these, and similar reddish and dark-colored hornblendic gneisses which are found in parts of the Malvern chain, in the northwest of Ireland, and possibly also in Anglesey. This series, according to Hicks, is unconformably overlaid by the Dimetian, brecciated beds which hold fragments of the older Lewisian gneiss. The strike in these older gneisses "is usually E. and W., or some point between that and N.W. and S. E."

Dr. Hicks concludes the above paper by remarking that the chief part of these ancient rocks in Great Britain "were until recently supposed to be either intrusive masses, or altered sediments belonging to tolerably recent times," and adds, "it is becoming more and more an acknowledged fact that the metamorphism of great groups of rocks does not take place so readily as was formerly supposed, but that some special conditions, such as do not appear to have prevailed over this area since pre-Cambrian times, were necessary to produce so great a result."

The reader in this connection is referred to the abstract of a memoir communicated by the writer to the British Association at Dublin in August, 1878, on The Origin and the Succession of the Crystalline Rocks of North America, which will be found in the Geological Magazine for that year (page 466), as well as in Nature, vol. xviii, page 443.

Montreal, February, 1880.

ART. XXXIV.—*Synopsis of the Cephalopoda of the Northeastern Coast of America*; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLVI. With Plates XII to XVI.

THE recent increase in the number of Cephalopods known to belong to this fauna is remarkable. Up to the year 1871, only three species were recorded. In 1872, an undetermined *Rossia* and *Octopus Bairdii* V. were discovered. Since that time fourteen additional species have been added, mostly by the writer, so that, at the present time, *eighteen species* are known from this coast. Four of these have been first discovered by the dredgings carried on by the U. S. Fish Commission, in charge of the writer. Six have been brought in by the Gloucester fishermen, from the Bank fisheries, among their valuable contributions to the collections of the U. S. Fish Commission and National Museum.

ARCHITEUTHIS.

In several former articles in this Journal,* the writer has recorded the occurrence of fourteen† American examples of the gigantic squids belonging to this genus, and apparently representing two species. Since the last of these notices, eight additional specimens have been found on the coasts of Newfoundland and Nova Scotia. In a somewhat extended article on the large cephalopods, recently published,‡ the author has given all the available facts in relation to the later discoveries, and has redescribed, in much greater detail than before, and with numerous illustrations, the various specimens formerly noticed, of which portions, more or less important, have been preserved. In the present article, the recent specimens are enumerated in order to complete the series of notices for this Journal. Since the capture of the fine specimen of *A. princeps*, at Catalina Bay, in 1877 (our No. 14, see Plate XII), which was preserved nearly entire in the New York Aquarium, the following have been recorded:

No. 15.—*Hammer Cove specimen*, 1876.

In a letter from Rev. M. Harvey, dated Aug. 25, 1877, he states that a big squid was cast ashore Nov. 20, 1876, at Ham-

* This Journal, vol. vii, p. 158, Feb., 1874; vol. ix, pp. 123, 177, Plates II–V, 1875; vol. x, p. 213, Sept., 1875; vol. xii, p. 236, 1876; vol. xiv, p. 425, Nov., 1877. Also, American Naturalist, vol. viii, p. 167, 1874; vol. ix, pp. 21, 78, Jan. and Feb., 1875.

† Of these, No. 6 proved to be the same as No. 3, and should be cancelled.

‡ Transac. Connecticut Acad., vol. v, pp. 177–258, Dec., 1879, to Feb., 1880, Plates XIII to XXV.

mer Cove, on the southwest arm of Green Bay, in Notre Dame Bay, Newfoundland. When first discovered by his informant it had already been partially devoured by foxes and sea-birds. Of the body, a portion 5 feet long remained, with about 2 feet of the basal part of the arms. The head was 18 inches broad; tail, 18 inches broad; eye-sockets, 7 by 9 inches; stump of one of the arms, 3·5 inches in diameter.

No. 16.—*Lance Cove specimen*, 1877 (*Architeuthis princeps ?*).

In a letter dated Nov. 27, 1877, Mr. Harvey gives an account of another specimen, which was stranded on the shore at Lance Cove, Smith's Sound, Trinity Bay, about twenty miles farther up the bay than the locality of the Catalina Bay specimen (No. 14). He received his information from Mr. John Duffet, a resident of the locality, who was one of the persons who found and measured it. His account is as follows: "On Nov. 21, 1877, early in the morning, a 'big squid' was seen on the beach, at Lance Cove, still alive and struggling desperately to escape. It had been borne in by a 'spring tide' and a high in-shore wind. In its struggles to get off it ploughed up a trench or furrow about thirty feet long and of considerable depth by the stream of water that it ejected with great force from its siphon. When the tide receded it died. Mr. Duffet measured it carefully, and found that the body was nearly 11 feet long (probably including the head); the tentacular arms, 33 feet long. He did not measure the short arms, but estimated them at 13 feet, and that they were much thicker than a man's thigh at their bases. The people cut the body open and it was left on the beach. It is an out-of-the-way place, and no one knew that it was of any value. Otherwise it could easily have been brought to St. John's, with only the eyes destroyed and the body opened." It was subsequently carried off by the tide, and no portion was secured.

No. 17.—*Trinity Bay specimen*, 1877.

Mr. Harvey also states that he had been informed by Mr. Duffet that another very large 'big squid' was cast ashore in October, 1877, about five miles farther up Trinity Bay than the last. It was cut up and used for manure. No portions are known to be preserved, and no measurements were given.

No. 18.—*Thimble Tickle specimen*, 1878. *Architeuthis princeps* (*?*).

The capture of this specimen has been described by Mr. Harvey, in a letter to the Boston Traveller, Jan. 30, 1879:

"On the 2d day of November last, Stephen Sherring, a fisherman residing in Thimble Tickle [near Little Bay Copper Mine, Notre Dame Bay], not far from the locality where the

other devil fish [No. 19] was cast ashore, was out in a boat with two other men; not far from shore they observed some bulky object, and, supposing it might be part of a wreck, they rowed toward it, and, to their horror, found themselves close to a huge fish, having large glassy eyes, which was making desperate efforts to escape, and churning the water into foam by the motion of its immense arms and tail. It was aground and the tide was ebbing. From the funnel at the back of its head it was ejecting large volumes of water, this being its method of moving backward, the force of the stream, by the reaction of the surrounding medium, driving it in the required direction. At times the water from the siphon was black as ink.

"Finding the monster partially disabled, the fishermen plucked up courage and ventured near enough to throw the grapnel of their boat, the sharp flukes of which, having barbed points, sunk into the soft body. To the grapnel they had attached a stout rope, which they had carried ashore and tied to a tree, so as to prevent the fish from going out with the tide. It was a happy thought, for the devil-fish found himself effectually moored to the shore. His struggles were terrific as he flung his ten arms about in dying agony. The fishermen took care to keep a respectful distance from the long tentacles, which ever and anon darted out like great tongues from the central mass. At length it became exhausted, and as the water receded it expired."

The body measured 20 feet from the beak to the extremity of the tail. The circumference of the body is not stated, but one of the tentacular arms measured 35 feet in length.

According to these measurements, this was the largest specimen yet found, it being nearly twice as large as No. 14.

No. 19.—*Three Arms specimen*, 1878. *Architeuthis princeps* (?).

Mr. Harvey has also given an account of this specimen, in the same letter to the Boston Traveller, referred to under No. 18. This one was found cast ashore after a heavy gale of wind, Dec. 2, 1878, by Mr. William Budgell, a fisherman residing at Three Arms, South Arm of Notre Dame Bay, near Little Bay mines. It was dead when found, and was cut up and used for dog-meat. Mr. Harvey's account is as follows:

"My informant, a very intelligent person, who was on a visit in that quarter on business, arrived at Budgell's house soon after he had brought it home in a mutilated state, and carefully measured some portions with his own hand. He found that the body measured 15 feet from the beak to the end of the tail. * * * * * * The circumference of the body at its thickest part was 12 feet. He found only one of the short arms perfect, which was 16 feet in length, being five feet longer

than a similar arm of the New York specimen [No. 14], and he describes it as thicker than a man's thigh."

No. 20.—*Banquereau specimen*, 1879.

This consists of the terminal part of a tentacular arm, which was taken by Capt. J. W. Collins and crew, of the schooner "Marion," from the stomach of a large and voracious fish (*Alepidosaurus ferox*), together with the only specimen hitherto discovered of the remarkable squid, *Histioteuthis Collinsii* V. The fish was taken on a halibut trawl-line, N. lat. 42° 49′; W. long. 62° 57′, off Nova Scotia, Jan., 1879. This fragment, after preservation in strong alcohol, now measures 18 inches in length. It includes all the terminal club, and a small portion of the naked arm below it.

No. 22.—*Brigus specimen*, 1879.

Mr. Harvey states that portions of another large squid were cast ashore near Brigus, Conception Bay, in October, 1879.

Two of the short arms, each measuring eight feet in length, were found, with other mutilated parts, after a storm.

No. 23.—*James's Cove specimen*, 1879.

From Mr. Harvey I have also recently received an account of another specimen, which was captured entire about the first of November last, at James's Cove, Bonavista Bay, N. F.

"Mr. Thomas Moores and several others saw something moving about in the water, not far from the stage. Getting into a punt, they went alongside, when they were surprised to see a monster squid. One of the men struck at it with an oar, and it immediately struck for the shore, and went quite upon the beach. The men then succeeded in getting a rope around it, and hauled it quite ashore. It measured 38 feet altogether. The body was about 9 feet in length, and two of its tentacles or horns were 29 feet each. There were several other smaller horns, but they were not so long. The body was about 6 feet in circumference."

This seems to have been a fine and complete specimen, about the size of the Catalina Bay specimen (No. 14). Unfortunately the fishermen, as usual, immediately destroyed it, and probably no portion was preserved.

Architeuthis Harveyi Verrill. (Harvey's giant squid).

Trans. Conn. Acad., v, p. 197, Plates xiii to xvia, Dec., 1879.
Megaloteuthis harveyi Kent, Proc. Zool. Soc. London, 1874, p. 178.
Architeuthis monachus Verrill, this Journal, vol. ix, pp. 124, 177, Pl. ii, iii, iv, 1875; vol. xii, p. 236, 1876; American Naturalist, vol. ix, pp. 22, 78, figs. 1–6, 10. 1875 (? *non* Steenstrup).
Ommastrephes harveyi Kent, Proc. Zool. Soc. London, 1874, p. 492.

PLATE XIII.

The principal diagnostic characters of this species, so far as determined, are as follows: Sessile arms unequal in size, nearly equal in length, decidedly shorter than the head and body together, and scarcely as long as the body alone. Tentacular arms, in extension, about four times as long as the short arms: about three times as long as the head and body together. Caudal fin small, less than one-third the length of the mantle, sagittate in form, with the lateral lobes extending forward much beyond their insertions; the posterior end tapering to a long acute tip. Jaws with a smaller notch and lobe than in *A. princeps.* Suckers of the sessile arms (so far as seen) mostly with numerous acute teeth all around the circumference, all similar in shape, but those on the inner margin smaller than those on the outer, and sometimes obsolete in certain suckers. Sexual characters are not yet determined.

Architeuthis princeps Verrill. (Giant squid).

Architeuthis princeps Verrill, this Journal, vol. ix, pp. 124, 181, Plate v, 1875; American Naturalist, vol. ix, pp. 22, 79, figs. 25–27, 1875; Trans. Conn. Acad., v. pp. 210 to 217. Plates xvii to xx, Jan. and Feb., 1880.

Ommastrephes (*Architeuthis*) *princeps* Tryon, Manual of Conchology, p. 185, Pl. 85, 1879, (figures copied and descriptions compiled from papers cited).

PLATE XII.

This species is distinguished from the preceding by the length and inequality of the short arms, of which the longest (ventral or subventral) exceed the combined length of the head and body by about one-sixth; by the denticulation of the suckers of the short arms, of which there are two principal forms, some having very oblique horny rings, with the outer edge very strongly toothed with broad, flat, acuminate teeth, and the inner edge slightly or imperfectly denticulated; the others having less oblique rings, with the acuminate denticles similar in form all around, though smaller on the inner margin; by the stronger jaws, which have a deeper notch and a more elevated tooth on the anterior edge; and by the caudal fin, which is short-sagittate in form, with the posterior end less elongated than in the preceding species.

Sthenoteuthis megaptera Verrill. (Broad-finned large squid).

Trans. Conn. Acad., v. p. 223, Pl. xxi, figs. 1–9, Feb., 1880.

Architeuthis megaptera Verrill, this Journal, vol. xvi. p. 207, 1878. Tryon, Manual of Conchology, vol. i, p. 187 (description copied from preceding paper).

The original specimen was found thrown ashore near Cape Sable, N. S. To this species is doubtfully referred a beak, taken on Sable I. Bank, in 280–300 fathoms, by Capt. Geo. A. Johnson and crew, of the schooner "A. H. Johnson."

The genus *Sthenoteuthis*, established to receive this species, differs from *Ommastrephes*, to which it is closely allied, in having, like *Architeuthis*, numerous small, smooth-rimmed suckers alternating with tubercles, on the proximal part of the 'club,' for the mutual adhesion of the long tentacular arms. The lateral arms are provided with very broad, thin marginal membranes. The caudal fin is very broad. Besides the type it also includes *S. Bartramii* (*Loligo Bartramii* Les.) from the Gulf Stream region, and probably *S. pteropus* (Steenst. sp.) from the Mediterranean and Bermuda.*

Ommastrephes illecebrosa Verrill. (Short-finned squid).

Loligo illecebrosa Lesueur, Journ. Phil. Acad. Nat. Sci., ii, p. 95, Plate x, figs. 18–21 (incorrect figures). Gould, Invert. Mass., ed. I, p. 318, 1841.

Ommastrephes sagittatus (pars) D'Orbig., Céph. Acétab., p. 345, Plate 7, fig. 1, (after Lesueur). Binney, in Gould's Invert. Mass., ed. II, p. 510, 1870 (excl. syn.), Plate xxvi, fig. 341–4 [341 is imperfect], *not* Plate xxv, fig. 339. Tryon (pars) Man. Conch., I, p. 177, Pl. 78, fig. 342 (very bad, after Lesueur), Pl. 79, fig. 343, 1879 (*not* Plate 78, figs. 341, 345).

Ommastrephes illecebrosa Verrill, this Journal, vol. iii, p. 281, 1872; Report on Invert. Viney. Sd., etc., 1873, pp. 441, 634.

Long Island Sound (Verrill) to Cumberland Gulf (Kumlein). Abundant from Cape Cod to Newfoundland. Saybrook, Conn. (U. S. Fish Com.) Vineyard Sd., Mass., large in winter, small in May (V. N. Edwards).

The Mediterranean form, usually identified with the *var. b*, of *Loligo sagittata* Lamarck, 1799,† is closely related to our species, but if the published figures and descriptions can be relied upon, it can hardly be identical. The American form has a more elongated body, with a differently shaped caudal fin, which is relatively shorter than *O. sagittatus*, as given by European authors. The figure given by Verany is, however, an exception in this respect, for in that the body is represented about as long as in some of our larger specimens.‡

Of our species, I have measured large numbers of specimens, preserved in different ways, and also fresh, and have found no great variation in the form and relative length of the caudal fin, among specimens of similar size, nor do the sexes differ

* A specimen from Bermuda is described in detail in Trans. Conn. Acad., vol. v, p. 228, but it lacked the 'clubs.'

† It seems more probable, however, that Lamarck's description applied, in part, to *O. Bartramii* (Les. sp.) of the Gulf Stream region. Blainville thus applied it.

‡ It should be remarked, however, that Lesueur's figure of *O. illecebrosa* shows the body too small and short in proportion to the size of the fin, and the fin wrong in shape, and occupying more than half the length of the mantle; the proportions of the arms are also erroneous. But Lesueur explains these defects by his statement that the figures were hasty sketches made for the sake of preserving the colors, and that he saved a specimen by which to correct afterwards his drawings and description, but the specimen saved turned out to be *L. pavo*, so that the original sketches were published without correction. Tryon's figure 342 is a reduced copy of one of Lesueur's, though not so credited.

in this respect. The two sexes are probably equally numerous, but in our collections the males usually predominate, and the largest specimens are usually males, though equally large females do occur. In 31 measured specimens, in alcohol, from various localities, and of both sexes, the average length from tip of tail to dorsal edge of the mantle was 6·96 inches; from tip of tail to insertion of fin, 2·59; average proportion of fin to mantle-length, 1 : 2·68. Among these the proportions varied from as low as 1 : 2·50, in some of the larger ones, (with mantle above 8 inches), up to 1 : 2·85, in the smaller ones, (with the mantle about 4 inches long). The caudal fin is about one-third broader than long, and its breadth is usually rather less than half the length of the mantle. In fresh specimens the tentacles can extend back beyond the base of the caudal fin. The portion of the tentacles bearing suckers is always less than half the whole length. The relative size of the suckers varies greatly in both sexes, perhaps in connection with the renewal of their horny rings, periodically.

In the *male* of our species the left ventral arm is strongly hectocotylized, nearly as in *Loligo*. Toward the tip the suckers of the outer row, for some distance, have their pedicels larger and longer, with swollen bases, while the suckers themselves gradually become smaller till they nearly or quite disappear, and then, close to the tip, they again become normal.

Taonius pavo Steenstrup. (Peacock squid).

Loligo pavo Lesueur, Journal Acad. Nat. Science Phila., ii, p. 96, Plate, 1821.
Loligopsis pavo Ferussac and D'Orb., Céph. Acét., p. 321, Pl. 4, figs. 1–8, (after Lesueur). Binney, in Gould, Invert. Mass., ed. II, p. 309, (but *not* the figure, Pl. xxvi). Tryon, Man. Conch., i, p. 163, Pl. 68, fig. 252, Pl. 69, fig. 253, 1879, (figures copied from Lesueur and D'Orb.).
Taonius pavo Steenst., Oversigt Kgl. Danske Vidensk. Selsk. Forh., 1861, pp. 70 and 85.

Sandy Bay, Mass. (Lesueur). Newfoundland (Steenstrup). No instance of the occurrence of this oceanic species on the New England coast has been recorded since the original specimen was described by Lesueur, in 1821.

Taonius hyperboreus Steenstrup. (Goggle-eyed squid).

Leachia hyperboreus Steenstrup, Kongelige Danske Vidensk. Selsk. Skrifter, 5te Række, iv, p. 200, 1856. (sep copies, p. 16).
Taonius hyperboreus Steenst., Oversigt Kgl. Danske Vidensk. Selsk., Forhandlinger, 1861, p. 83. Verrill, this Journal, xvii, p. 243, 1879.
Loligopsis hyperboreus Tryon, op. cit., p. 162, (inaccurate translation, after Steenstrup).

Near the northern edge of the Gulf Stream, W. long. 55°, Jan., 1879 (Thomas Lee). Greenland (Steenstrup).

Histioteuthis Collinsii Verrill. (Webbed squid).

This Journal, xvii, p. 241, March, 1879. Tryon, op. cit., i, p. 166, 1879, (copied from preceding). Verrill, Trans. Conn. Acad., v, p. 234, Plates xxii and xxvi. Feb., 1879.

PLATE XIV.

The only specimen known was obtained from the stomach of a large fish (*Alepidosaurus ferox*), taken by Capt. J. W. Collins and crew of the schooner "Marion," in deep water off Nova Scotia, N. lat. 42° 49′; W. long. 62° 57′.

Rossia Hyatti Verrill. (Hyatt's bob-tailed squid).

This Journal, vol. xvi, p. 208, Sept., 1878. Tryon, Man. Conch., i, p. 166, 1879, (description compiled from preceding).

PLATE XV, figures 1 and 2.

This species has been taken in numerous localities, by the dredging parties of the U. S. Fish Commission, in 1877, 1878 and 1879, off Cape Cod; in Mass. Bay; off Cape Ann, in the Gulf of Maine; off Cape Sable, N. S.; and off Halifax, N. S. It occurs in 40 to 150 fathoms. Its relatively large eggs are laid in small clusters in the large oscules or cavities of several species of sponges. It has also been received through the Gloucester halibut fishermen, from the Banks, off Nova Scotia.

This species has a strong general resemblance to *R. glaucopis* Lovén, as figured in the admirable work of G. O. Sars, but the latter has shorter lateral arms, and the suckers of the sessile arms are in two rows, while they are four-rowed in our species.

Rossia sublevis Verrill. (Smooth bob-tailed squid).

***Rossia sublævis* Verrill, this Journal, xvi, p. 209, 1878. Tryon, Man. Conch., i, p. 160, 1879, (description compiled from preceding).**

PLATE XV, figure 3.

Taken by the dredging parties of the U. S. Fish Commission in the trawl-net, at numerous localities, in 1877, 1878 and 1879, in 50 to 140 fathoms, off Mass. Bay; in Mass. Bay; off Cape Cod; off Cape Sable, N. S.; and off Halifax. Also recently brought in by the Bank fishermen, of Gloucester.

Sepiola leucoptera Verrill. (Butterfly squid).

***Sepiola leucoptera* Verrill, this Journal, vol. xvi, p. 378, 1878. Tryon, Man. Conch., i, p. 158, 1879, (description copied from preceding, with remarks.)**

PLATE XV, figures 4 and 5.

Three specimens were taken by the U. S. Fish Com., in the trawl-net, 30 miles east from Cape Ann, Mass., 110 fathoms, August, 1878. One specimen was taken off Cape Cod, 123 fathoms, with the bottom temperature 41° F., August, 1879.

The last named specimen, (Plate xv, fig. 5) when fresh was about 31^{mm} long, exclusive of the arms. In this the head, above, in front of the eyes, was white; back and the base of the fins thickly spotted with brown; posterior part of the back with an emerald-green iridescence. Sides of the body, below the fins, and posterior end of the body, silvery white. A large shield-shaped

ventral area of brown, with a bright blue iridescence, and bordered with a band of brilliant blue, occupies most of the lower surface. Fins transparent, whitish, except at base. Lower side of head, siphon and outer bases of arms, light brown. Eyes blue above, green below. The fins are large, nearly as long as the body.

Loligo Pealei Lesueur. (Long-finned squid.)

Journ. Acad. Nat. Sci. Philad., vol. ii. p, 92, Plate 8, 1821.

Férussac and D'Orbigny, Céph. Acét., p. 311, Pl. xi, figs. 1–5, Pl. xx, figs. 17–21. Binney in Gould's Invert. Mass., ed. 2, p. 514, Pl. 25, fig. 340, (figure erroneously referred to *O. Bartramii*). Verrill, Report on Invert. Vineyard Sd., pp. 440, 635 (sep. copies, p. 341), Pl. xx, figs. 102–105, 1877. Tryon, Man. Conch., I, p. 142, Pl. 51, figs. 134–140, (figs. from Fér. and D'Orb.)

Loligo punctata Dekay, Nat. Hist. N. Y., Mollusca, p. 3, Pl. 1, fig. 1, 1843, (young.)

South Carolina to Massachusetts Bay.

This is the *common squid* from Cape Hatteras to Cape Cod. In Long Island Sound and Vineyard Sound it is very abundant, and is taken in large numbers in the fish-pounds and seines. It is comparatively scarce north of Cape Cod. Large specimens were taken in the pounds at Provincetown, Mass., August, 1879. As in all other squids, the length of the caudal fin, in proportion to that of the body (mantle), increases with age, even after maturity. For this species, in specimens having the mantle from 4 to 5 inches long, the ratio of the fin to the mantle usually varies from 1 : 1·80 to 1 : 1·90 ; with the mantle 6 to 7 inches long, the ratio usually becomes 1 : 1·65 to 1 : 1·75 ; in the largest specimens, with the mantle 10 to 13 inches long, the ratio varies from 1 : 1·56 to 1 : 1·70. This variation is independent of sex, and is due mostly to the ordinary changes by growth. The ratio of the breadth of the caudal fin to the length of the mantle, in the larger specimens, ranges from 1 : 2·15 to 1 : 2·40, varying considerably according to the mode of preservation. The suckers in the two central rows of the tentacular club, are large and remarkably high ; the rim is closely and sharply denticulated, one or three minute denticles alternating with the larger ones.

Var. borealis Verrill. Four specimens, taken in 1878, at Annisquam, Mass., on the north side of Cape Ann, and sent to me by Professor A. Hyatt, differ so decidedly from the typical ones that it seems desirable to give the form a distinctive name, as a variety or geographical race. Two are females, filled with eggs. When a larger series can be examined it may even prove to be a distinct species. They have the general form and appearance of the pale-colored *L. Pealei*, with the caudal fin broader than usual. Ratio of fin-length to mantle, 1 : 1·62 ; of fin-width to mantle-length, 1 : 1·82. Length of mantle, above, in one female, 7·30 inches ; of caudal fin, 4·5 ; to end of longest sessile

arms, 10·7. The anterior dorsal lobe of the mantle-edge is larger and longer than usual, and the 'pen,' while having the general form of that of *L. Pealei*, tapers more gradually anteriorly, and has a narrower, more tapered, more acute and stiffer anterior tip. But the most obvious peculiarity is the unusual smallness of the suckers, both of the tentacles and short arms, which are little more than half as large as those of typical *L. Pealei* of the same size. The largest of the median suckers of the tentacular club are only 2^{mm} in diameter of aperture; the largest of those on the 3d pair of arms, $1·5^{mm}$. The rims of the suckers are white, and their denticulation is similar to that of the typical form, but finer.

Loligo pallida Verrill. (Pale long-finned squid).

Report on Invert. Viney. Sd., in Rep. U. S. Com. Fish and Fisheries, i, p. 635, [341], Pl. xx, figs. 101, 101a, 1873. Tryon, op. cit. p. 143, Pl. 52, figs. 141, 142, (des. and figs. copied from preceding).

This is closely allied to *L. Pealei*, and may finally prove to be only a geographical variety of it, but among the very numerous specimens, of both forms, that I have already examined, I have not found intermediate ones. The principal differences are the larger and flatter median suckers of the tentacular clubs, which also have darker colored and more strongly denticulate rims; the larger suckers of the sessile arms; a stouter body in both sexes; a larger and broader caudal fin, the ratio of the breadth of the fin to the mantle-length, in the larger specimens (with mantle 7 to 9 inches long), being from 1 : 1·80 to 1 : 1·95, while in *L. Pealei*, of corresponding size, the ratio is 1 : 2·15 to 1 : 2·30.

This form has been received, hitherto, only from the western part of Long Island Sound, where it is abundant, with the schools of *menhaden*.

Parasira catenulata Steenstrup.

Octopus tuberculatus Risso (?), Hist. nat. de l'Eur. merid., iv, p. 3, 1826 (t. D'Orbig.)
Octopus catenulatus Férussac, Poulpes, Pl. vi, bis, ter., 1828 (t. D'Orbig.)
Philonexis tuberculatus Fér. and D'Orbig., Céph. Acét., p. 87, Pl. vi, bis, ter.

A fine specimen of this interesting species was taken in Vineyard Sound, Mass., by Mr. V. N. Edwards, in 1876.* It was not known previously from the American coast, and has been regarded as peculiar to the Mediterranean. The total length of this specimen is 8 inches; of mantle, 2; circumference of body, 6; length of dorsal arms, from eye, 5·4; of second pair, 3·7; of third pair, 3·30; of fourth pair, 5·30. Color, above, deep violet; beneath, yellowish. The remark-

* This is the same specimen that was referred to under *Octopus granulatus*, in this Journal, xvi, p. 210, 1878. The specimen had been mislaid, and at that time was not to be found. It was recorded from memory, and only an imperfect examination of it had been made when received.

able tubercles of the ventral surface, mostly have five ridges converging to each, rarely six. In all other respects it agrees with the figures of Férussac and D'Orbigny. According to Targioni-Tozzetti, *P. catenulata* is distinct from *P. tuberculata.* If so, our species should bear the former name.

Octopus Bairdii Verrill. (Baird's Octopus.)

This Journal, vol. v, p. 5, Jan., 1873; American Naturalist, vol. vii. p. 394, figs. 76, 77, 1873; Amer. Assoc. for Adv. Sci. for 1876, p. 348, Pl. 1, figs. 1, 2, 1874. G. O. Sars, Mollusca Regionis Arcticæ Norvegiæ, p. 339, Pl. 33, figs. 1 to 10, (♀) Pl. xvii, figs. 8ᵃ to 8ᵈ (dentition and jaws). 1878. Tryon, Man. Conch., i. p. 116, Pl. 32, figs. 37, 38 (description and figures from the papers by A. E. V.)

In addition to the localities previously given, this species has been taken in numerous localities off the coasts of Massachusetts and Nova Scotia, by the dredging parties of the U. S. Fish Commission, in 1877, '78 and '79. It is common in 50 to 150 fathoms, both on muddy and on hard bottom. Both sexes occur, the females less frequently. The sexes show but little difference, except the hectocotylized third right arm of the male.

The Gloucester fishermen have brought in several specimens from the banks, off Nova Scotia and Newfoundland.

Professor G. O. Sars has taken it, off the Norwegian coast, in 60 to 300 fathoms.

Octopus piscatorum Verrill. (Fishermen's Octopus.)

This Journal, vol. xviii, p. 470, Dec., 1879.

Two specimens of this species, both females, have been obtained. The first was from LeHave Bank, off Nova Scotia, 120 fathoms, taken by Capt. John McInnis and crew, of the schooner "M. H. Perkins," Oct., 1879; the second was taken by Capt. David Campbell and crew, of the schooner "Admiral," near the Grand Bank, in 200 fathoms, Dec., 1879.

This species resembles *O. Grönlandicus*, of which the males alone have been described, and may prove identical.

Octopus obesus Verrill. (Stout Octopus.)

This Journal, vol. xix, p. 137, Feb., 1880.

One male, taken in 160 to 300 fathoms, east of Sable Island, N. S., by Chas. Ruckly, of the schooner "H. A. Duncan."

Octopus lentus Verrill. (Soft Octopus.)

This Journal, vol. xix, p. 138, Feb., 1880.

One specimen only, a female, presented by Capt. Samuel Peeples and crew, of the schooner "H. M. Perkins." It was taken near LeHave Bank, N. S., in 120 fathoms.

Stauroteuthis syrtensis Verrill. (Webbed devil-fish.)

This Journal, vol. xviii, p. 468, Dec., 1879.

PLATE XVI, figs. 1 to 5.

The only known specimen of this curious species was taken ı N. lat. 43° 54′; W. long. 58° 44′, about 30 miles E. of Sable sland, N. S., in 250 fathoms, by Capt. Melvin Gilpatrick and rew, of the schooner "Polar Wave," Sept., 1879.

EXPLANATION OF THE PLATES.

PLATE XII.

rchiteuthis princeps V. (No. 14). General figure; from the recently preserved specimen; restored, in part, in accordance with the measurements of the freshly caught specimen; $\frac{1}{13}$ natural size. Drawn by the author.

PLATE XIII.

gure 1.—*Architeuthis Harveyi* (No. 5). Head and arms, $\frac{1}{8}$ natural size, from a photograph of the specimen when freshly caught. The back of the head rests upon an oar so as to cause the beak to protrude, while the arms hang down in a reversed position. The diameter of the bathing tub was 38·5 inches: *a*, left, and *a′*, right ventral arms; *b*, left, and *b′*, right arms of the third pair; *c*, left, and *c′*, right arms of the second pair; *d′*, right dorsal arm, mostly concealed behind the others; *e*, left and *e′*, right tentacular-arms, folded several times over the oar; *i* to *iv*, the 'club'; *i* to *ii*, the 'wrist'; *ii* to *iii*, the part bearing large suckers; *iii* to *iv*, the terminal division; *o*, the beak.

igure 2.—Part of the body and caudal fin of the same specimen, $\frac{1}{8}$ natural size, from a photograph made at the same time with the preceding; *u*, mantle cut open; *t*, tip of tail; *b*, right and *l*, left lateral lobes of caudal fin.

PLATE XIV.

Histioteuthis Collinsii Verrill. Side-view of the head and arms; from the preserved specimen, $\frac{4}{5}$ natural size. Drawn by J. H. Emerton.

PLATE XV.

igure 1.—*Rossia Hyatti.* Dorsal view, enlarged $1\frac{1}{2}$.
igure 2.—The same. A young specimen, enlarged $1\frac{1}{2}$.
igure 3.—*Rossia sublevis.* Ventral view, enlarged $1\frac{1}{2}$.
igure 4.—*Sepiola leucoptera.* Young, ventral view, enlarged 3 diameters.
igure 5.—The same. A larger specimen, taken in 1879, enlarged $1\frac{1}{2}$.

PLATE XVI.

igure 1.—*Stauroteuthis syrtensis.* Dorsal view, $\frac{3}{10}$ natural size.
igure 2.—The same. Lower side of head; *s*, siphon; *e*, eye; *a*, the pore.
igure 3.—The same. The siphon, turned back.
igures 4 and 5.—The upper and under jaws of the same, enlarged $2\frac{2}{3}$ diameters.

ART. XXXV.—*Notices of Recent American Earthquakes.* No. 9; by Professor C. G. ROCKWOOD, Jr., Princeton, N. J.

IN these notices, as heretofore, those based upon *single* newsaper items, and which could not be otherwise verified, are rinted in smaller type, and the source of the information is ıdicated.

I must again express my indebtedness for information reeived, to J. M. Batchelder, Esq., of Boston, to the U. S. Monthly Weather Review, and also to President J. W. Dawson f Montreal, Professor F. E. Nipher of St. Louis, and Professor L. A. Rice, of Burlington, Vt.

1878, June 9. A shock at Granada, Nicaragua, at 4.30 P. M., direction N.W. to S.E., duration seventeen seconds. This is evidently the same shock already reported at San José, Costa Rica. —III, xvii, p. 166.

June 16. Two severe shocks at Cerro de Pasco, Peru.

June 17. A slight shock at Granada, Nicaragua, at 11.15 A.M., direction N.W. to S.E., duration eleven seconds.

June 19. A severe shock at Cerro de Pasco, Peru at 1.30 A. M.

Oct. 31. At San José, Costa Rica, a very feeble shock at 9.30 A. M.

Nov. 3. At the same place, a feeble shock at 5.30 P. M.

Nov. 8. At the same place, a feeble shock at 8.15 P. M.

Nov. 23. At the same place, a quite strong shock.

Nov. 12. At Unalaska Island, Alaska, a slight shock at 2.30 A. M.—*U. S. Weather Review.*

Nov. 18. For additional notices of the earthquake on this day in Missouri, (already reported, III, xvii, p. 162), see vol. xvii, p. 260.*

Nov. 26. A brief shock at Alajuela, Costa Rica, at 1.40 A. M.

Dec. 9. A severe shock at Red Bluff, Cal., at 3.20 P. M., lasting fifteen or twenty seconds.

Dec. 17. A slight shock at Yuma, Arizona, at 4 P. M., lasting eight seconds; felt also at Campo, Cal., where two shocks were reported, lasting about two seconds, direction from S. W., with rumbling noise.

Dec. 24. A slight shock at 9 P. M. at Flushing, N. Y., from N. to S., with rumbling noise.—*U. S. Weather Review.*

Dec. 28. A slight shock at Schoharie, N. Y., at 9.32 P. M.; felt also in other towns north of there, to a distance of 15 miles.

1879, Jan. 9. A severe shock at Arequipa, Peru, at 11.50 P. M.

Jan. 12. At Iquique, Peru, a long and violent shock about midnight, with subterranean noise.

Jan. 12. Apparently simultaneous with the above, a severe shock was felt in northern and central Florida. It occurred about 11.45 P. M. and affected the country bounded on the north by a line joining Tallahasse and Savannah, Ga., and on the south by a nearly parallel line from Punta Rassa on Tampa Bay through Okahumpka in the interior, to Daytona on the Atlantic coast. At most places two shocks were noticed, lasting altogether about thirty seconds. The statements of directions are very discordant, with however an apparent preference for N.W. and S.E. This direction agrees pretty well with the statements of time, which vary from 11.40 and 11.45 at Lake City and Jacksonville, to 11.50 at Savannah and Daytona, 11.55 at St. Augustine and Gulf Hammock, and 12 P. M. at Okahumpka, thus roughly indicating a progress from N.W. to S.E. The reports are not sufficiently exact to form a basis for any estimate of velocity.

Jan. 30. A strong shock between 10 and 11 A. M. at Colima, Mexico.—*U. S. Weather Review.*

Feb. 4. A shock at Visalia, Cal., at $0^{h}\cdot 8^{m}$ A. M., lasting five seconds, with rumbling noise, and seven seconds later a second heavier shock lasting nine seconds. The motion "appeared to come from the S.E. or E.," and was felt in the surrounding country.

Feb. 12, 18, 26. At San José, Costa Rica, feeble shocks on 12th at 10.46 P. M.; on 18th at 3.10 A. M.; on 26th at 6.00, 6.10, and 6.30 A. M., with a stronger one at 4.40 P. M.

Feb. 19. A shock at San Francisco, Cal., a few minutes after 5 A. M.—*N. Y. Times.*

March 18. A strong shock at Alajuela, Costa Rica, at 0.15 A. M. and at San José at 0.17 A. M., oscillations E. to W., lasting ten seconds.

March 25. A shock was felt about 7.30 P. M. along the Delaware River below Philadelphia. It extended from Chester, Pa., to beyond Salem, N. J., a distance of about 30 miles, being felt most strongly on the east side of the river, where it was accompanied by a noise resembling thunder.

April 3, 4. At San José, Costa Rica, at 11.25 A. M. on the 3d, a feeble shock; and at 11.44 A. M. of the 4th, two strong shocks with an interval of five to seven seconds. At 2 P. M. of the same day a shock was felt at Puntarenas.

April 9. At San José, Costa Rica, two shocks at 11.15 and 11.34 A. M., the first and stronger one lasting about twenty seconds. The same shocks were reported from Alajuela at 11.07 and 11.25 A. M.

April 14. A shock at Norfolk, N. Y., at 11.15 A. M., from W. to E., lasting about forty seconds.

May 16 or 17. An earthquake in the morning at Vera Cruz, Mexico, and inland to Cordova and Orizaba. I have this from two sources differing in the day, although evidently referring to the same shock.

May 25. At 5.30 P. M., a rather heavy shock at St. Georges, Bermuda; felt also about the same hour in the islands of Porto Rico, St. Croix and Tortola, the nearest part of the Antilles.

May 26. Slight shock at Princeton, Cal., at 8.40 P. M.—*U. S. Weather Review.*

May 29, 30. On the night between these days, at 6.30 P. M. and 1.30 A. M., severe shocks occurred in Costa Rica, destroying some houses at San José, Alajuela and Grecia, and felt more lightly at Aspinwall, Panama and other places.

June 3. At 9.32 A. M. on Atka Island, Alaska, eight sharp shocks in rapid succession, lasting about two seconds each, direction S.SE. to N.NW.

June 11, 12. A light shock at 10 P. M. felt at Montreal and east and southeast from there as far as Waterloo and Frelighsburg. At Montreal it is described as "loud rumbling, slight shock and

continuation of rumbling." The direction was said to be N. to S. Some persons reported a second light shock and rumbling at 2 A. M. on the 12th.

June —. The Sacramento (Cal.) Union of June 28, speaks of a "recent earthquake at Virginia City," (Nev.) which was felt at the surface but *not* in the deeper mines. No more exact account has been obtained."

July 11. Two severe shocks at Bogota, Colombia, the first about 9 P. M., lasting ten seconds, the second about 11 P. M., lasting thirty seconds. They were accompanied by a slight rumbling noise; direction S.W. to N.E. The damage to property was slight.

July 26. A shock at Cairo and Mound City, Ill. at 11.45 A. M., lasting three seconds. Motion N. to S.

July 30. A violent shock at St. Thomas, (West Indies) at 11.35 A. M., lasting forty seconds.—*Nature.*

Aug. 1. A sharp shock at St. Thomas, (West Indies).—*J. M. B.*

Aug. 10. A severe shock was felt at Dominica, (West Indies), "at 1.20 A. M., and at intervals until 1.52 there were tremulous movements of the earth." A noise accompanied the first shock, after which "there was an interval of perfect quiet until 1.30 when subterranean noises like the booming of distant guns attracted attention; and then at intervals varying from two to five minutes, six of these discharges were counted, and following each there came a gentle tremulous movement." Dominica is stated to be "essentially of volcanic origin and contains three active geysers." —From a letter in *Nature*, xx, p. 431.

Aug. 10. At 1.15 P. M. a very light shock at Los Angeles Cal.; stronger and followed by a tidal wave at St. Monica 13 miles west; and quite severe at San Fernando about the same distance north.

Aug. 18. A shock at Fiske's Mills, Sonoma county, California.—*J. M. B.*

Aug. 21. The country between Lakes Erie and Ontario was severely shaken about 3 A. M. The earthquake was reported from Buffalo, Lockport and Niagara, on the New York side, and from various places as far west as Beamsville and Welland on the Canada side. At most places an explosion was heard and at St. Catharines the shock was strong enough to cause the church bell to make two taps. The time stated at Buffalo and Lockport is "1.30 to-day." If not an error, this would indicate another shock. Inquiry failed to remove the uncertainty. No report mentioned *two* shocks.

Sept. 24. A violent shock occurred in the southern part of Iceland, being most severe near Krísuvík. Slight local earthquakes had frequently occurred at Krísuvík during the previous eighteen months.

Sept. 25. A shock at 9.10 P. M. at Memphis, Tenn., lasting six seconds, direction N.W. to S.E. It was felt also at Gayoso, Mo.,

where "the sound appeared to be in the S.W. and the vibration to travel to the N."

Oct. 2. A sharp shock at 6.30 A. M., felt at Oakland and other places around San Francisco Bay.

Oct. 2. A strong shock in the morning at Arequipa, Peru, lasting thirty seconds. —*U. S. Weather Review.*

Oct. 24. At New Haven, Conn., at 6.12 P. M. two slight shocks, felt also at Bridgeport.

Oct. 25. Two shocks at 10.30 P. M. at Peterboro, N. H.—*J. M. B.*

Oct. 26. A slight shock at Winsborough, S. C.—*U. S. Weather Review.*

Nov. 3. A slight shock at Contoocook, N. H., at 7.15 A. M.

Nov. 13, 14, 15, 16. Numerous shocks in Valparaiso, Chili.—*London Times.*

Nov. 18. A slight shock at 10.40 A. M. in Costa Rica.—*U. S. Weather Review.*

Nov. 25. A slight shock at Boise City, Idaho, lasting about two seconds, vibration E. to W.; felt also at Idaho City, 35 miles north, where another faint shock was noticed on the 26th.

Dec. 7. A slight shock at Los Angeles, Cal., at 8.15 P. M., lasting about two seconds.—*U. S. Weather Review.*

Dec. 12, 13. Two distinct shocks from W. to E. at 7 P. M. of the 12th, and 2 A. M. of the 13th, were felt at Charlotte, S. C., and in the surrounding country within a radius of eleven miles.

Dec. 21. In the district of San Salvador, C. A., was felt the first of a series of earthquakes which continued with greater or less violence up to and after Jan. 1, 1880. Shocks of especial severity occurred on Dec. 27, and at La Libertad at 7.30 P. M. on Jan. 1. Fears were entertained for the safety of the capital and other towns in the interior. Fuller details are hoped for in due time.

Dec. 29. A shock at Yankton and Fort Sully, Dakota, at 12.30 A. M. with rumbling noise.

1880, Jan. 9. A shock about the Bay of Monterey, Cal., felt at Santa Cruz, Gonzales and Hollister, about 5.45 A. M., lasting 15 to 20 seconds, direction N.E. to S.W.

Jan. 22, 23. Severe shocks were felt at Key West, in Havana and the western part of Cuba and in the Isle of Pines. The principal and most widely felt shocks occurred about 11 P. M. of the 22d and 4 A. M. of the 23d; with others more local in character about 9 P. M. of the 23d, 4 A. M. and 1 P. M. of the 26th, and on the morning of the 29th. No damage was done at Havana, but at Vuelta Abajo and San Christobal, twelve miles distant, many buildings were thrown down and some lives lost. The direction of motion was S.W. to N.E., and a subterranean roaring was heard.

Feb. 8. A slight shock near Ottawa, between 8 and 9 P. M.—*N. Y. Tribune.*

Feb. 23, 24. Light shocks at San Christobal, Cuba, at 6.30 P. M. and 3.20 A. M., the latter accompanied by an explosive noise.

Princeton, N. J., March 2, 1880.

ART. XXXVI.—*Observations on the Height of Land and Sea Breezes, taken at Coney Island;* by O. T. SHERMAN.

THE following observations were taken at Coney Island with the captive balloons of the American Aeronautic Society, S. A. King, aeronaut in charge. Captain Howgate furnished the observer.

With the exception of the hotels, no height rises to interrupt the flow of the wind. We might expect, therefore, to find the sea breeze and its counter current undisturbed. The standard thermometer employed was of the Signal Service pattern, made by James Green, and carefully tested by the observer. The aneroid barometers were kept compared with a standard mercurial instrument at the surface. The anemometer, of Robinson's pattern, furnished by James Green, was used to measure the velocity of the wind at the top of the ascent, and also at the bottom. In the other cases, the forces were estimated.

The record was commenced as the balloon left the earth and continued without interruption till the balloon attained its highest point. At the top, the velocity of the wind was recorded by a "five minute" observation. On the descent the same plan was followed.

From the barometric readings, reduced to the mercurial standard, the heights were deduced by Loomis' table as given by Guyot. A comparison of these heights with those deduced from the length of the rope in use showed a close agreement. The thermometric readings reduced to the standard thermometer were then plotted in a curve whose ordinates were heights, and the abscissas, the degrees of the thermometric scale. The ascent and descent giving somewhat discordant values, a free hand curve was drawn between them. The positions of the curve are given in the annexed table. The force of the wind was treated in a like manner. The observed directions were then plotted opposite the heights. When discordant at one height, they were referred to that one of the sixteen equal divisions of the compass which lay between them. The whole was then referred to the mean of the times of leaving and regaining the earth, an interval of about fifteen minutes. New York time was employed. The results are given on the following page.

A slight inspection of the return rates of change shows that the return current has influenced the temperature of the air around it to a noticeable extent.

We may consider the observed wind as composed of the wind produced by a great storm in progress, and the sea or

The first line in the table gives the heights above the ground in feet. The upper numbers indicate the temperature in Fahrenheit degrees. The lower the direction and velocity of the wind. —— indicates no record of direction, or rather a direction between the two neighboring directions.

Day.	Hour.	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
1879.	h m													
July 31	10 15	78·5 NE. 3	76 —— 2·3	74·8 N. 2	74·0 —— 2·1	73·5 NNW. 2·3	73·3 —— 2·4	73·3 NW. 3						
" 31	2 46	79·0 SW. 2·8	77·2 S. 2·6	77·0 S. 2·0	77·2 S. 1·8	77·7 —— 1·3	78·2 Calm.			NW.*				
" 31	7 26	74·0 SSW. 2·8	73·4 —— 2·8	73·5 S. 3·0	74·0 —— 3·0	74·2 —— 2·8	75·0 SSE. 2·2							
Aug. 1	9 46	77·0 SSW. 3	76·6 —— 3	75·2 SW. 4	74·3 SW. 5·6	74·2 SW. 7	74·2 SW. 7·5							
" 1	10 54	82·0 SSW. 5	77·2 —— 5	76·0 SSW. 5·5	75·2 —— 6·0	74·8 —— 6·5	74·4 SSW. 6·5							
" 2	9 0	76·8 SW. 3	75·0 —— 6·3	75·2 WSW. 7·0	75·8 W. 6·8	76·0 W 6·3								
" 2	1 55	84·0 SSE. 9·0	84·2 SSE. 7	84·6 S. 5·0	85·2 S. 4·5	85·6 ——	86·0 SSW. 5·0	86·2 —— 4·5	87·0 SW. 4·5					
" 10	1 19	70·5 NNE. 2·0	68 2 —— 5·0	67·6 —— 5·4	67·3 —— 5·4	67·0 N. 6·0	67·0 —— 7·5	66·4 —— 8·7	66·2 —— 8·0	66·0 —— 6·0	65·6 —— 4·5	65·3 —— 5·0	65·0 NNW. 5·2	64·7 NNW. 5·7
" 10	3 10	73·3 NW. ·3	72·7 —— 5·3	72·2 —— 7·5	71·8 —— 9·0	70·8 —— 11·0	69·5 —— 13·5	68·8 —— 16·5	68·0 —— 16·5	68·0 —— 14·0	68·0 —— 12·0	67·6 —— 11·5	67·2 —— 11·7	66·8 NNW. 12·0
" 10	5 42	72·8 NW. ·3	71·0 NW. 4	70·3 —— 4	69·8 —— 3	69·2 —— 3	68·5 —— 3·8	68·0 NW. 4	67·5 —— 4	67·0 NW. 4	66·8 —— 4·0	66·4 —— 4·0	66·2 —— 4·0	66·0 NW. 3·8
" 11	2 10	79·0 SSE. ·8	74·8 SSE. 8·3	73·9 —— 9·3	73·0 S. 8·2	72·4 S. 7·0	71·7 SSW. 6	71·2 —— 5·5	70·6 SSW. 5·2	70·6 —— 5·0	70·5 —— 5·2	70·4 —— 7·5	70·0 SSW. 10·5	
" 12	10 50	74·5 S. 5	73·2 —— 5	72·7 —— 4·5	72·7 SW. 4·5	72·7 SW. 4·5	72·7 SW. 4·5	72·0 WSW. 3·6	72·0 WSW. 4·0	72·0 W. 4·5	72·0 —— 5·0	71·5 WNW. 6	71·3 —— 6	71·1 NW. 6·3
" 13	11 50	78·0 SSE. 7·5	71·5 SSE. 8·4	71·3 SSE. 8·4	70·6 S. 8·4	70·0 SSW. 7·6	69·6 —— 5·8	69·5 SW. 3·8	69·2 WSW. 4·2	69·2 W. 4·7	69·2 WNW. 5·8	68·7 WNW. 6·8	68·2 WNW. 10·5	68·3 WNW. 12
" 14	1 42	80·3 SSE. 7·2	80·0 —— 4	79·2 —— 4·5	78·7 S. 7·5	78·2 SW. 9·8	77·8 SW. 11	77·4 —— 11·5	77·8 W. 12					

* Shown by a toy balloon as compared with the captive.

land breeze. The sea breeze blows perpendicular to the coast, or about southeast. To obtain the storm wind, I examined the 7·35 A. M. maps of the Signal Service, but since the observations were taken almost directly under areas of maximum pressure, the examination gave no useful results. I therefore adopted a method based upon the following considerations. Of all those directions and velocities which combined with the direction of the sea breeze can produce the resultant, the storm breeze is that which remains when the sea breeze vanishes; the fact that the sea breeze vanishes is shown by the other component remaining undisturbed. For example, on August 13, the observed wind was S.S.E., velocity 7·5 miles. This might be produced either by S. 4·5, S.E.; S.S.W. 4, S.E., S.W. 3, S.E., etc., but of these, S.W. 3 most nearly satisfies the condition that it shall be observed by itself. The surface breeze therefore ends at about 650 feet from the surface of the sea, while above 700 feet a current from the land evidently deflects the breeze toward the northwest. Proceeding with each of the other cases in the same way a mean may be taken. In this manner we have drawn up the following table. The values, though necessarily approximate, gain much from our inability to launch the balloon save on calm days. The sign < implies that the given value is probably too high.

Day.		Hour.			Surface breeze ends.	Return breeze begins.	Return breeze ends.
1879.		h	m				
July	31	10	15	A. M.	<175 feet.	<400 feet.	
		2	46	P. M.	<500 feet.	About 750	
		7	26	P. M.	<375 feet.	<400 feet.	
August	1	9	46	A. M.	200? feet.	<300? feet.	
		10	54	A. M.	Above	the highest	point reached.
	2	9	0	A. M.	<200 feet.	<250 feet.	
		1	55	P. M.	<200 feet.	<600 feet.	
	10	1	19	P. M.	<400 feet.	<500 feet.	< 900 feet.
		3	10	P. M.	<500 feet.	500 feet.	<1100 feet.
		5	42	P. M.	None.	None.	
	11	2	10	P. M.	<825 feet.	<900 feet.	
	12	10	50	A. M.	<600 feet.	<800 feet.	
	13	11	50	A. M.	<650 feet.	<700 feet.	1050 feet?
	14	1	42	P. M.	<300 feet.	<400 feet.	

It becomes evident that both current and counter current are low in the atmosphere. They will perhaps serve to explain a fact often noticed, that though we could plainly see the steam from the locomotives as they whistled, yet could hear no sound though nearly above the track.

r. XXXVII.—*On a New Method of Spectrum Observation;* by J. N. LOCKYER.*

N anticipation of my report on the Methods of Mapping ctra, which I have been requested to prepare for the Solar nmittee, I beg to present to them the following account of ıe recent work which has been suggested during the prepa- on of that report.

n the Philosophical Transactions for 1873 (p. 254) I gave an orical account showing how, when a light source such as a rk or an electric arc is made to throw its image on the slit ı spectroscope, the lines had been seen of different lengths, I also showed by means of photographs how very definite se phenomena were. It was afterwards demonstrated that mical combination or mechanical mixture gradually reduced spectrum by subtracting the shortest lines, and leaving y the long ones.

n the hypothesis that the elements were truly elementary, explanation generally given and accepted was that the short s were produced by a more complex vibration imparted to "atom" in the region of greatest electrical excitement, that these vibrations were obliterated or prevented from ing by cooling or admixture with dissimilar atoms.

ubsequent work, however, has shown† that of these short s *some* are common to two or more spectra. These lines I e called basic. Among the short lines, then, we have some ch are basic, and some which are not.

'he different behavior of these basic lines seemed, therefore, uggest that not all of the short lines of spectra were, in re- y, true products of high temperature.

'hat some would be thus produced and would therefore be ımon to two or more spectra we could understand by ap- ling to Newton's rule: "Causas rerum naturalium non res admitti debere quam quæ et veræ sint et earum phæ- ıenis explicandis sufficiant," and imagining a higher disso- ion. It became, however, necessary to see if the others ıld also be accounted for.

have already given to the Royal Society a preliminary ac- nt of the extraordinary, because unexpected, phenomena changes observed in the spectra of vapors of the elemen- ' bodies when volatilized at different temperatures in vac- ı tubes. Many of the lines thus seen alone and of sur- sing brilliancy, are those seen as short and faint in ordinary

* Received for publication from the author.

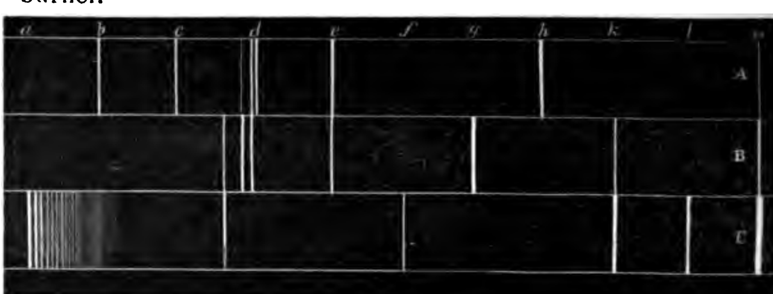
† Proc. Roy. Soc., vol. xxviii, p. 159.

methods of observation, and the circumstances under which they are seen suggest, if we again appeal to the above rule, that many of them are produced by complex molecules.

In this case the appeal lies to the phenomena produced when organic bodies are distilled at varying temperatures; the simplest bodies in homologous series are those volatilized at the lowest temperatures; so that on subjecting a mixture of two or more liquids to distillation, at the beginning a large proportion of the more volatile body comes over, and so on.

At any particular heat-level, then, some of the short lines may be due to the vibrations of molecular groupings produced with difficulty with the temperature employed, while others represent the fading out of the vibrations of other molecular groupings produced on the first application of the heat.

In the line of reasoning which I advanced a year ago,* both these results are anticipated, and are easily explained. Slightly varying fig. 2 of that paper, we may imagine furnace A to represent the temperature of the jar spark, B that of the Bunsen burner, and C a temperature lower than that of the Bunsen burner.



A. Highest temperature. C. Lowest temperature.

Then in the light of the paper the lines *b* and *c* would be truly produced by the action of the highest temperature, *c* would be short and might be basic, while of the lines *h* and *m*, *m* would be short and could not be basic, because it is a remnant of the spectrum of a lower temperature.

To make this reasoning valid we must show then that the spark, or better still the arc, provides us with a summation of the spectra of various molecular groupings into which *the solid metal which we use as poles* is successively broken up by the action of temperature.

We are not limited to solid metals; we may use their salts. In this case it is shown in the paper before referred to† that in very many cases the spectrum is one much less rich in lines.

I have therefore attempted to gain new evidence in the re-

* Proc. Roy. Soc., vol. xxviii, p. 162. † Phil. Trans., 1873, p. 258.

quired direction by adopting a method of work with a spark and a Bunsen flame, which Col. Donnelly suggested I should use with a spark and an electric arc. This consists in volatilizing those substances which give us flame spectra in a Bunsen flame and passing a strong spark through the flame, first during the process of volatilization, and then after the temperature of the flame has produced all the simplification it is capable of producing.

The results have been very striking; the puzzles which a comparison of flame spectra and the Fraunhofer lines has set us find, I think, a solution; while the genesis of spectra is made much more clear.*

To take an instance, the flame spectrum of sodium gives us as its brightest, a yellow line, which is also of marked importance in the solar spectrum. The flame spectra of lithium and potassium give us, as their brightest, lines in the red which have not any representatives among the Fraunhofer lines, although other lines seen with higher temperature are present.

Whence arises this marked difference of behavior? From the similarity of the flame spectrum to that of the sun in one case, and from the dissimilarity in the other, we may imagine that in the former case—that of sodium—we are dealing with a body easily broken up, while lithium and potassium are more resistant; in other words, in the case of sodium, and dealing only with lines recognized generally as sodium lines, the flame has done the work of dissociation as completely as the sun itself. Now it is easy to test this point, for if this be so then (1) the chief lines and flutings of sodium should be seen in the flame itself and (2) the spark should pass through the vapor after complete volatilization has been effected without any visible effect.

Observation and experiment have largely confirmed these predictions. Using two prisms of 60° and a high-power eyepiece to enfeeble the continuous spectrum *of the densest vapor produced at a high temperature*, the green lines, the flutings recorded by Roscoe and Schuster, and another coarser system of flutings, so far as I know not yet described, are beautifully seen. I say largely, and not completely, because the double red line and the lines in the blue have not yet been seen in the flame, either with one, two or four prisms of 60°, though the lines are seen *during volatilization* if a spark be passed through the flame. Subsequent inquiry may perhaps show that this is due to the sharp boundary of the heated region, and to the fact that they represent the vibrations of molecular groupings more complex

* I allude more especially to the production of triplets, their change into quartets, and in all probability into flutings, and to the vanishing of flutings into lines, by increasing the rate of dissociation.

than those which give us the yellow and green lines. The visibility of the green lines, which are short, in the flame, taken in connection with the fact that they have been seen alone in a vacuum tube, is enough for my present purpose.

With regard to the second point, the passage from the heat-horizon of the flame to that of the spark, after volatilization is complete, produces no visible effect, indicating that in all probability the effects heretofore ascribed to *quantity* have been due to the presence of the molecular groupings of greater complexity. *The more there is to dissociate, the more time is required to run through the series, and the better the first stages are seen.*

Let us now turn to lithium.

Seeing that the red line is absent while the violet lithium line is strong among the Fraunhofer lines, we may imagine that the flame has not done the work of dissociation in the case of lithium as completely as the sun does it, so that (1) the other lines of lithium should not be visible, even with the new precautions, in the flame spectrum, and (2) a passage from the heat-level of the flame to that of the spark after volatilization should produce the other lines which we know to exist in the spectrum of the metal in the orange, blue and violet.

Experiment and observation have also confirmed this result, so far as the yellow and blue lines go; that in the violet is difficult of observation.*

We next come to potassium.

The potassium lines usually recorded as not seen in a flame, but which are observed with a spark, are not very brilliant; nor are they strong among the Fraunhofer lines. Seeing, therefore, that a high temperature does not greatly develop them, we may expect to find them in the flame. They are almost all there when they are looked for with proper precautions, but those in all probability present in the sun are brightened on passing the spark, showing apparently that the flame volatilizes with some difficulty the molecule which gives the line in the red.

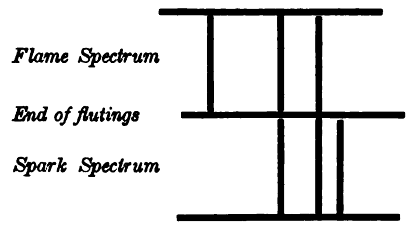
The flame spectrum of magnesium perhaps presents us best

* The way in which the lines in the flame are unaffected by the spark strikingly reminds me of the following remarks of Angström and Thalén: "The Fraunhofer lines can in general be divided, according to their appearance, into two classes; the one sharply defined and tolerably deep black, the other by no means so decidedly marked either as to form or color. These two different kinds of lines are, as regards their appearance, very happily characterized by the opinion expressed on a former occasion, that the former, especially when the illumination is feeble, look as if they were situated considerably in front of the faint ground on which the latter seem to lie. The most prominent lines of the former class almost all proceed from iron; and those which remain, after the iron-lines are abstracted, belong to the other metals; calcium, manganese, chromium, etc."—("Angström and Thalén on the Fraunhofer Lines, together with a Diagram of the Violet Part of the Solar Spectrum." Upsala, 1866, p. 5.)

with the beautiful effects produced by the passage from the lower to the higher heat-level, and shows the important bearing on solar physics of the results obtained by this new method of work.

In the flame the two least refrangible of the components of *b* are seen associated with a line less refrangible, so as to form a triplet. A series of flutings and a line in the blue are also seen.

On passing the spark, all these but the two components of *b* are abolished. We get the wide triplet replaced by a narrow one of the same form, the two lines of *b* being common to both, thus—



When the line in the blue disappears on passing the spark, two new lines are seen. The spark lines are in the sun, but the less refrangible member of the wide triplet and the blue line seen in the flame are absent.

The following are the details of some of the experiments which have been made on the above points:—

Experiment No. I.—Two pieces of platinum wire were supported in a Bunsen flame at a distance from one another of about three millimeters. They were then connected with a Holtz machine, in order that the spark might be passed inside the flame.

An image of the platinums was then thrown on the slit of the spectroscope by means of a lens. The spectroscope used had two dense flint prisms of 60°.

A piece of charcoal soaked in solution of sodium chloride was put into the base of the flame first, and then just below the platinum, and the spectrum observed; it consisted simply of the yellow line D. The spark was passed and the spectrum again observed; it now consisted of D plus the lines of hydrogen and some air lines, the red and green Na lines and the green flutings being still absent

Experiment No. II.—Same arrangements, except that a large induction coil was substituted for the Holtz machine. The same results were obtained with the sodic chloride.

Experiment No. III.—Metallic sodium was next tried. It was found that when the metal was put into the flame just

below the platinums the green line and the flutings were seen without the spark, that is, at the ordinary temperature of the flame. On introducing the sodium into the lower part of the flame, the green double (λ 5687·2 and 5681·4) and the flutings were not seen, either with or without the spark.

Experiment No. IV.—Same arrangements as No. II, with metallic sodium, and with a small blowpipe instead of Bunsen.

In this experiment the flame spectrum showed, besides the yellow line (D), the green double (λ 5687·2 and 5681·4), and also the flutings in the green, those in the red being absent. As soon as the spark was passed, the green double (λ 5687·2 and 5681·4) became brighter, while the flutings vanished.

In these observations the sodium was put into the flame *just below the platinums.* When put into the bottom of the flame, the D line was seen alone.

Experiment No. V.—A glass tube ½ inch in diameter was prepared, about six inches in length, having two platinums sealed into it at a distance of four inches from each other. A bulb was blown at each end, so that the spectrum might be examined with the tube end-on. A piece of sodium was put into the tube, and the latter exhausted with a Sprengel pump. An Argand burner was placed at one end of the tube, in order that the absorption of the vapor, as well as its radiation, might be observed. The metal was then very gradually heated by a Bunsen flame.

After the heating had gone on for about twenty minutes the absorption line of D appeared; this gradually increased in intensity.

On passing the spark along the tube, the bright lines of sodium appeared, the green double (λ 5687·2 and 5681·4), being distinguishable after D had been seen for a little time alone.

The temperature was now increased and the absorption spectrum again examined. The flutings in the green gradually made their appearance, D increasing in intensity, the green line being invisible. Afterwards the flutings in the red came in.

On passing the spark the absorption spectrum, consisting of the red and green flutings disappeared instantaneously, and the green double was seen very bright; after the passage of the spark D dark was much increased in breadth.

The quantity of hydrogen given off during the change prevented the passage of the spark, and the observations had to be discontinued. As soon as some of this had been pumped out the same observations were repeated with the same results.

Experiment No. VI.—An experiment was made with lithium chloride in Bunsen flame, with the same arrangement as in Experiment No. 1.

Γhe flame spectrum with the dispersion employed showed Li line except the red one (λ 6705·2). On passing the spark m the Holtz machine, the yellow line (λ 6102·0) and the ıe line (λ 4602·7) appeared as bright as the red line. The ne results were obtained on repeating the experiment with large induction-coil.

Experiment No. VII.—Potassium nitrate was tried by the thod previously described in Experiment No. 1.

Γhe flame spectrum consisted as usual of the red lines (λ 7697 l 7663) and the blue line (λ 4045), very faint.

Γhe effect of the spark was to bring out the yellow lines (λ out 5800), those in the green (λ about 5840), and the red uble (λ 6946 and 6913) out of the flutings visible in the red, double at 7697 and 7663 not being affected. The experint was repeated with the induction-coil, and the same obserions made, with the additional one that the spark also ghtly intensified the blue line.

Experiment No. VIII.—On repeating the experiment with tallic potassium, the same phenomena were more markedly served, the lines about λ 5800, and other lines more refrangi-, were visible as very faint objects in the flame; they were ıch strengthened, however, by the passage of the spark.

Experiment No. IX.—Some potassium was volatilized by the ırk in front of the slit of the sun-spectroscope and comparin of the positions of the lines with the Fraunhofer lines .de. It is believed that λ 5829·0, 5802·0, 5782·5 are all 'ersed in the solar spectrum. The less refrangible member the red double (λ 6946) was next compared, and was unubtedly absent from the sun. These observations, however, rendered extremely difficult on account of the fluted appearce of the yellow lines, and must be repeated with a stronger n and the electric arc. The spectroscope employed had three sms, one of 60° and two of 45°.

Experiment No. X.—The flame spectrum of magnesium was amined, a green triplet was observed which was at first sight ken for *b*. Measurements of the lines, however, showed that less refrangible member was less refrangible than *b*, and d a wave-length 5209·8, and that the other two members re b^1 and b^2 respectively. A fresh charge of magnesium was t into the flame and the spark passed; the original triplet s now no longer visible, the line at 5209·8 having vanished, t b^4 was now seen forming with b^1 and b^2 a triplet of similar m on a smaller scale.

According to Thalén, there are three blue lines of magneım at w.l. 4481·0, 4586·5, and 4703·5. These lines were oked for in the flame with and without the spark. Without spark only one line was visible in this region; its position

was found by comparison with the solar spectrum, to be at w.l. 4570·3, and coincident with no Fraunhofer line. The passage of the spark abolished this line, at the same time bringing in the two lines given by Thalén at w.l. 4481·0 and 4703·5, both of which are reversed in the solar spectrum.

No line was seen at Thalén's w.l. 4586·5, the nearest approach to which was the line seen at the temperature of the Bunsen flame at w.l. 4570·3, a difference of more than sixteen divisions of the scale.

I am now preparing maps showing the phenomena observed at various heat-levels. I think it is not too much to hope that a careful study of such maps, showing the results already obtained or to be obtained, at varying temperatures, controlled by observation of the condition under which changes are brought about, will, if we accept the idea that various *dissociations* of the molecules present in the solid are brought about by different stages of heat, and then reverse the process, enable us to determine the mode of evolution by which the molecules vibrating in the atmospheres of the hottest stars *associate* into those of which the solid metal is composed. I put this suggestion forward with the greater confidence, because I see that help can be got from various converging lines of work. To some of these I may briefly allude here:—

1. We have the lines present in the solar spectrum and absent from it.

Example.—The red potassium line present in the flame is absent from the sun; some of the other lines are present.

2. We have the varying thicknesses of the lines of any one element in the sun to compare with the thicknesses produced at different temperatures in the laboratory.

Example.—The various lines of magnesium, notably *b*, the most refrangible line given by Thalén and the other blue line.

3. We have the remarkable behavior of metals vaporized in a vacuum at the lowest temperatures.

Example.—Sodium gives us D, potassium gives us the triplet in the green-yellow; calcium gives us the line in the blue; thus separating those lines from all the others of those metals.

4. We have the remarkable behavior of the same vapors under like circumstances, the temperature alone being changed; when this is increased lines visible under ordinary conditions are brought in, and are seen in different parts of the tube, so that each line in turn (and therefore, I presume, each molecule which produces it) is separated from those with which it is generally seen in company.

Example.—By increasing the temperature we get the green line of sodium without D, and some of the magnesium lines have been seen separated from the others.

5. We have the power of determining the lower states by means of absorption phenomena and then of observing the radiation of the vapors produced by the passage of a feeble current of electricity.

Example.—The fluted spectrum of sodium described by Roscoe and Schuster is instantly abolished by this means and a brightening of the green and a considerable thickening of the dark yellow lines is seen.

6. May we consider the existence of these molecular states as forming a true basis for Dalton's law of multiple proportions? if so, then the metals in different chemical combinations will exist in different molecular groupings, and we shall be able by spectrum observations to determine the particular heat-level to which the molecular complexity of the solid metal induced by chemical affinity corresponds.

Examples.—None of the lines of magnesium special to the flame spectrum are visible in the spectrum of the chloride either when a flame or a spark is employed. The facts recorded in my papers, printed in the Philosophical Transactions some years ago, on the spectra of salts and mixtures, seem all explained in this way.

I think then that the method of mapping, to be complete, should not only show the metallic lines as produced at various temperatures compared with the Fraunhofer ones, but that for each metal investigations should be made and recorded for as many heat-levels as possible, and for various chemical groupings such as

$Cr\,O$	Fe_2Cl_6
$Cr\,O_3$	$Fe\,Cl_2$
Cr_2O_3	Fe
Cr,	

to give examples, with a view of investigating the facts, to see whether we can trace a molecular evolution in each case.

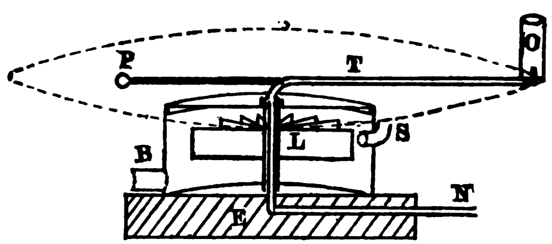
Further, the "basic lines recorded by Thalén will require special study with a view to determine whether their existence in different spectra can be explained or not on the supposition that they represent the vibrations of forms, which, at an early stage of the planet's history, entered into combination with other forms, differing in proximate origin, to produce different "elements."

ART. XXXVIII.—*The Presentation of Sonorous Vibrations by means of a Revolving Lantern;* by HENRY CARMICHAEL, Ph.D. (Göttingen).

AT the meeting of the American Association for the Advancement of Science at Hartford in 1874, a paper was read by the author on "A new method for the presentation of sound waves," in which was described the arrangement represented in fig. 1.

The principal novelty of this consists in a small lantern containing a coal-gas flame connected with a König's manometric capsule, the upright lantern being so placed at the end of a horizontal arm that it could be rapidly revolved in the horizontal plane.

1.



The frequent destruction of the glass cylinder forming the lantern led to the advantageous substitution of a mica cylinder. The cylinder O is open at both ends, and on being slightly inclined backward from the vertical of the plane of revolution it effectually screens the flame which would be otherwise immediately extinguished.

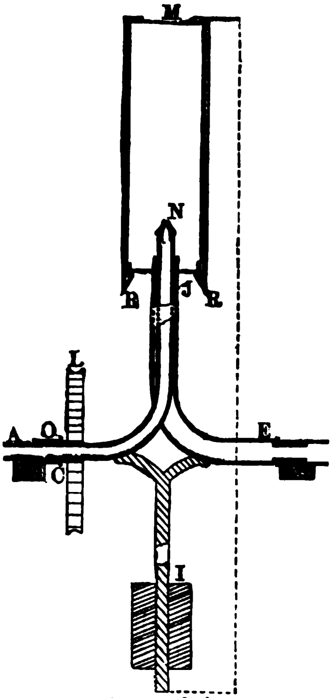
The lantern arm T is bent in to the vertical axis of revolution, and by an enlargement at this place it is made to slip over and form a gas-tight joint with the right-angled tube N, which is firmly fastened in the base block E. The rotation of the lantern is conveniently maintained by a small water-wheel L attached to the vertical shaft. The water enters the case at S and escapes at B. That the lantern may run smoothly the moment of the lantern O is counteracted by the adjustable weight P.

Flexible tubing connects N with König's manometric capsule. When no sound enters the capsule a smooth band of light appears, which, on the introduction of sound, is broken into a series of teeth, large or small, simple or compound, according to the nature of the sound. The peculiarities of this flame-band can be seen from the most distant parts of an audience room.

ıgh the performance of this instrument was highly ıry, it was exceeded in the following modification, 7hich, though hitherto unpublished, has been publicly me during the last three years.

lvantages of a sensitive flame, which is made to re- the vertical plane, must be obvious. Not only are all ı representing the sound ought within the field of nd the foreshortening of upon either side avoided, ıe introduction of oxygen lantern the brilliancy of : is greatly increased. It tant that the lantern and ›ving parts be made as possible. The thin mica he lantern is conveniently into shape by placing it sheet of thin metal some- ger than itself, the whole ortion of which within a ır of the edge has been The thin metal is folded edges of the mica which brought into contact, and then held in place by a ;rip bent traversely upon il it has the section of the fig. 3). The mica is thus ›ent without cleaving or ;.

2.



¼ natural size.

istal end of the cylinder :d with a perforated disc top of a pepper-box, and to the disc are fastened : springs, RR, by which the cylinder is quickly and ›cured to the flange at the opposite end. The well- atite tip N should have such an internal diameter that gas under full head will send the flame to the top of rn.

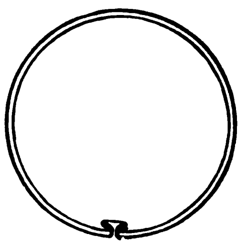
›ntral gas supply-tube is bent at right angles into the evolution, and by means of a leather washer is made in the socket O. Commencing just below the gas-tip, ;en supply-tube is made concentric with the former, ng bent at a right angle, it leaves it to form with it the the instrument. The joints at C and E are made gas- h little friction by the slight inward spring of the iron

The lantern is revolved by a multiplying wheel, or by a powerful clock-work, when a uniform motion is required. Fig. 4 shows the general arrangements of parts.

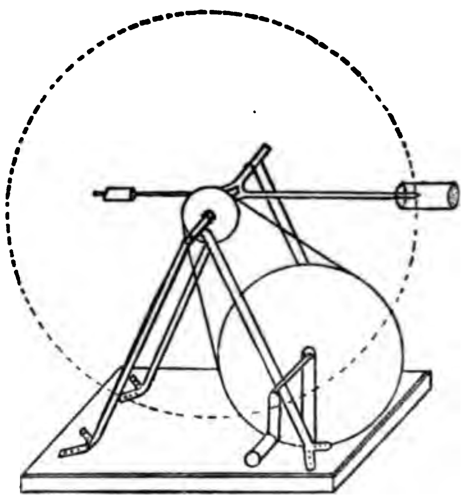
When the oxygen is diluted with two measures of air it is more easily regulated as a supporter of combustion. The brilliancy of the flame is considerably increased by conducting the coal gas through a sponge saturated with "gasoline."

By regulating the flow of gases and giving the flame a rapid rotation, a continuous brilliant ring is produced, which is broken up into saw-like teeth, characteristic of the pitch, in-

3.



4.



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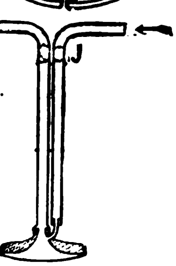


tensity and quality of the entering sounds. A shrill whistle produces teeth so fine that they are barely visible at a distance of thirty feet. A loud low sound of the human voice affords teeth of the height of the lantern, three or more inches long, with one or two harmonic teeth surmounting the fundamentals. A rough roar yields large jagged teeth, exceedingly complicated and curious.

On turning down the flame the teeth are reduced to brilliant dots, with smaller dots between them if the harmonics be present. It is curious to observe that no trace of flame can be seen between these dots, which may be three inches or more apart. It is not to be presumed, however, that the flame is extinguished, as it is possible to arrange the flow of gases so that the flame is invisible during a complete rotation, and yet be restored by simply altering the proportion of the inflammable gases.

For investigating the motions of sonorous bodies an attachment is substituted for the manometric capsule, which may

be called the manometric pad, which is represented in figure 5. This consists simply in a wooden funnel, the mouth of which is covered with thin rubber, and the neck connected with two flexible tubes, one of which brings the supply of coal gas, and the other conveys the sonorous vibrations to the revolving lantern. On placing the manometric pad distended with gas in direct contact with vibrating strings, bells, tuning-forks, etc., their movements are readily studied in the flame band. By sliding the pad over the sonorous body the node and vibration segments are readily located. The interference and extinction of sounds may easily be presented by this apparatus.

The revolving flame was designed primarily for the elucidation of the principles of sound, and this it renders simple by the clearness and brilliancy of its phenomena, as well as the direct view of the vibrating flame, which it gives instead of the image usually seen.

For purposes of research the lantern is given a uniform rate, and the length of the flame band made a simple multiple of the wave length. There appears to be no limit to the velocity of rotation, although when the radius is made shorter or the velocity made greater than has been found as yet necessary, it will probably be preferable to introduce the jet at the outer end of the lantern, as only thus can the heated gases of combustion flow, as the force of rotation would impel them. A lantern upon the end of a long wand, to which a thin flexible tube leads, is easily constructed by any one, and when waved back and forth gives only less effectually the phenomena of the revolving lantern. Owing to the brilliancy of the flame, there is presumably no difficulty in the way of the direct photography of it.

ART. XXXIX.—*On the Chemical Composition of Childrenite;* by S. L. PENFIELD.

AFTER the publication by Messrs. Brush and Dana* of their paper in which the new species, eosphorite, was described and shown to be closely related both physically and chemically to childrenite, they proposed to me to make a new investigation of the composition of the latter species with a view to deciding the uncertainty in regard to its true formula. Professor Brush very kindly placed at my disposal a suitable specimen from Tavistock out of his collection. From this the material for the following analysis was taken. The crystals were small, of a yellow-brown color, and were very carefully picked

* This Journal, July, 1878.

from the siderite and oxide of iron with which they were associated. Only lustrous crystals were accepted, and any doubtful material was discarded. Between eight and nine tenths of a gram were thus obtained. Analysis I is a complete analysis made on a little over half a gram; it was conducted with the greatest care and a special test was made for alkalies, so that they might be determined quantitatively if present. As Church in his analysis found iron sesquioxide present, the remaining three tenths of a gram of the mineral were tested quantitatively with potassium permanganate; the result indicated 26·08 per cent of FeO, varying only 0·12 per cent from gravimetric determination of iron protoxide in the same portions; so that we may conclude that the mineral really contained no iron sesquioxide. After titrating with potassium permanganate the solution was reserved, and P_2O_5, Al_2O_3 and FeO determined in it gravimetrically (analysis II) as a control on the other analysis.

	I.	II.			Ratio calculated from analysis I.
P_2O_5	30·19	29·98	·212		1.
Al_2O_3	21·17	21·44	·208		·98
FeO	26·34	26·20	·368		
MnO	4·87		·069	·458	2·16
CaO	1·21		·021		
H_2O	15·87		·882		4·16
Quartz	·10				
	99·95				

The above ratio corresponds closely to the following:

$P_2O_5 : Al_2O_3 : RO : H_2O = 1 : 1 : 2 : 4$ (R=Fe, Mn, and Ca),

and to the empirical formula $R_2Al_2P_2O_{10}, 4H_2O$, which may be written

$$Al_2P_2O_8 + 2R(OH)_2 + 2aq \text{ or } \left.\begin{matrix} R_3P_2O_8 \\ Al_2P_2O_8 \end{matrix}\right\} + \left.\begin{matrix} R(OH)_2 \\ Al_2(OH)_6 \end{matrix}\right\} + 4aq,$$

or the same as that made out for eosphorite.

The formula in this case corresponds to the following percentage composition: P_2O_5 30·80, Al_2O_3 22·31, FeO 26·37, MnO 4·87 H_2O 15·65=100. This agrees satisfactorily with analysis I.

Note on the relation between Childrenite and Eosphorite; by GEORGE J. BRUSH and E. S. DANA.

In our former paper, to which Mr. Penfield refers, we showed that childrenite and eosphorite were crystallographically closely homœomorphous. Thus the axial ratios for the two species are:—

	c (vertical).	b (macro-diagonal.).	a (brachy-diagonal).
Childrenite, Tavistock (Cooke)	0·667	1·294	1·000
Eosphorite, Branchville	0·663	1·287	1·000

We showed also that the two species were *related* in chemical composition, although there was a wide variation between the results of analysis in the two cases, the formula of eosphorite being clearly established, while that of childrenite was still in doubt. The analysis of Mr. Penfield seems to set at rest the latter question and to show further that the two species have the same formula, but differ in this: that childrenite contains chiefly iron (26·54 FeO, 4·87 MnO) and eosphorite chiefly manganese (7·40 FeO, 23·51 MnO). Eosphorite then should be considered merely as a sub-species under childrenite, related to it in the same way that the lithiophilite from the same locality is to triphylite. The points of difference between the two minerals in physical characters and mode of occurrence have been mentioned in our former paper, and need not be here repeated.

ART. XL. — *Observations on the Planet Lilaea;* by Professor C. H. F. PETERS. (Communication to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., March 6, 1880.)

OF a planet detected on Feb. 16, I communicate the following observations, all that have been hitherto obtained.

1880.	Ham. Coll. m. t.	α (213)	δ (213)	No. of comp.
Feb. 16.	$14^h 30^m 52^s$	$10^h 51^m 44^s{\cdot}51$	$+13^\circ 16' 7''{\cdot}2$	15 ringmicr.
Feb. 18.	11 29 13	10 50 17·35	13 29 18·6	3 ringmicr.
Feb. 19.	14 26 54	10 49 23·97	13 37 11·6	12 ringmicr.
Feb. 27.	8 26 29	10 43 4·67	14 30 47·2	10 fil. micr.
Mar. 2.	9 2 39	10 39 43·29	14 57 26·2	10 fil. micr.

The observation of Feb. 18 is a very indifferent one, and, besides, the comparison star of that day is only approximately determined in zones. The planet appeared of the 11th magnitude. It has received the name *Lilaea.*

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *Photographs of Star Spectra.*—Mr. W. HUGGINS in a note to the French Academy gives some results of his late investigations on stellar spectra. The telescope employed had a metallic mirror; and the spectroscope consisted of a prism of Iceland spar and two quartz lenses. Its slit was about one-fourteenth of a millimeter in width. The spectroscope was fixed upon the telescope so that this slit was precisely at the focus of the reflecting mirror of the telescope; and a special arrangement kept the

image of the star upon the slit during the time of the exposure of the negative. The slit was also made in two halves which made it possible to photograph the solar spectrum, or that from any source of light, just above the spectrum of the star under examination. The photographs obtained were only $0^{m}·013$ in length from G to O in the ultra violet; but the definition was so perfect that at least seven fine lines between H and K in the solar spectrum could be counted. The measurement of the lines was made by a microscope provided with a micrometer and the wave lengths were determined by a graphical method by the aid of Cornu's map of the ultra violet rays of the solar spectrum, and Mascart's table of wave lengths of the cadmium lines. Six spectra obtained belong to the white stars of the type of Vega. All the stars of this type give spectra of essentially the same type. The typical lines consist of twelve very large lines nebulous at their edges. The two less refrangible lines of this group coincide with the hydrogen lines $\lambda=4340$ (near G) and $\lambda=4101$ (h), the third line with H of the solar spectrum. The strong line K of the solar spectrum in only represented by a fine line, and even this line appeared to be absent in Sirius and in η of the constellation of the Great Bear. The lines H and K of the solar spectrum coincide with two bright lines of calcium and are attributed to its vapor. It is important to notice, however, that another pair of more refrangible lines of calcium, $\lambda=3736·5$ and $\lambda=3705·5$ on Cornu's map do not coincide with the strong lines in these stars. The relative position of these twelve lines are in a certain sense symmetrical. Each pair of lines nearing each other the more refrangible they are. They seem, therefore, to belong to one body. Mr. Huggins' note contains a table of the wave lengths of these twelve typical lines. He finds that in the most typical stellar spectra the continuous spectrum can be traced beyond S; but there are no lines more refrangible than $\lambda=3699$ to be seen. As the star approximates to the solar type, the twelve typical lines become smaller and less nebulous at their edges; other lines present themselves and the line, which corresponds to K in the solar spectrum, becomes large and nebulous. In the spectrum of Arcturus, however, the line K is larger than in the solar spectrum, and the whole extent of the photograph of the spectrum is full of fine and broken lines. The photographic spectra of Jupiter, Mars and Venus give no evidence of change due to the atmospheres of these planets, and the photographs of portions of the Moon's surface under different conditions of illumination also give the same negative result. Mr. Huggins is about to apply his method to the spectra of gaseous nebulæ and to different parts of the solar spots.—*Comptes Rendus*, No. 2, Jan., 1880, p. 70. J. T.

2. *Direct measure of the work of Electrical Induction.*—Herr A. VON WALTENHOFEN, guided by the principle that the work which a current of electricity, from a battery, affords in a conductor must be equal to the work which it is necessary to exert

in order to produce the same current by means of induction, has been led to a determination of the mechanical equivalent of heat. He made use of the magneto-electric machine of constant current of Siemens and Halske, which is described in the twelfth volume of Carl's Repertorium. A dynamometer for estimating the work done in rotating the armature of the machine is described by the author at some length. It is found that 0·13 *mkg* (in round numbers) is the value of the induction work per second in order to produce the electromotive force of one Daniell cell in a circuit of 1 S.E resistance. To produce the electromotive force of one Bunsen cell, 0·4 *mkg* is necessary. Reckoning a horse power at 75 *mkg*, the expression $0{\cdot}0053 \frac{n^2}{w}$ represents the induction work necessary to produce an electromotive force of n Bunsen cells, through a resistance of w S.E. To this must be added the useless work. According to W. Thomson and Jenkin, a Daniell cell in circuit of one unit resistance affords in each second a quantity of heat represented by the number 0·00030633; by comparing the value 0·13 *mkg* or more exactly 0·13109 *mkg* with this result, Von Waltenhofen finds 427·94 for the mechanical equivalent of heat. Under other conditions of work, the numbers 421·21 and 420·6 are obtained.—*Annalen der Physik und Chemie*, No. 1, 1880, p. 81. J. T.

3. *Mechanical Equivalent of Heat.*—In the proceedings of the American Academy of Arts and Sciences, Part I, 1879, is an exhaustive memoir upon thermometry and the mechanical equivalent of heat, by Professor ROWLAND of the Johns Hopkins University, Baltimore, Maryland. No treatise on the measurement of heat has appeared which is more valuable than this. The results obtained by Professor Rowland for the mechanical equivalent of heat differ from those of Joule only one part in 430. The investigation also showed a decrease in the specific heat of water as the temperature rises. Complete details are given of the apparatus employed. J. T.

4. *A Dispersion Photometer.*—Messrs. PERRY and AYRTON describe a new photometer for measuring very strong light. The light is made to pass through a concave lens and is thus dispersed at a short range over a large surface. The authors believe that the amount of light absorbed by the lens can be accurately estimated, and think that measures can be made more accurately in this way than in the methods of measuring lights from a great distance.—*Phil. Mag.*, Feb., 1880, p. 117. J. T.

II. GEOLOGY.

1. *The present state of the Evidence bearing upon the Question of the Antiquity of Man;* by T. McK. HUGHES, M.A., Woodwardian Professor of Geology, Cambridge. (Read before the Victoria Institute, 1879).—The following paragraphs, discussing the evidence as to Man's existence in or before the Glacial era in

Europe, and the remarks succeeding, by Professor Dawkins, are cited from a paper bearing the above title.

We may dismiss at once the case [of supposed human remains], reported from the Dardanelles, of works of art found in deposits said to be of Miocene age. The descriptions* prove that it was not given on the authority of one competent to judge in such a case, and it never has been confirmed.

In beds said to be Miocene, at Thenay, near Pontlevoy, the Abbé Bourgeois found flints which he supposed were dressed by man. These flints are now exhibited in the Museum at St. Germains, where I saw them with Sir Charles Lyell several years ago, and again with others since. Some of them seemed entirely natural, common forms, such as we find over the surface everywhere, broken by all the various accidents of heat and frost and blows. A few seemed as if they might have been man's handiwork,—cores from which he had struck off flakes such as we know were used by early man, of which I show examples. Yet this is not quite clear, for, had the evidence been good that they were found in place there still would have been a doubt whether they were man's work. But when we came to inquire about the evidence that they occurred in beds of Miocene age, we learned that only those that we put down as natural were found by the Abbé himself; the others were brought in by workmen, picked up, we may suppose, upon the heaps turned over by their spades, and so perhaps just dropped down from the surface.

Next in the Crag the teeth of sharks, bored through, as if for wear, were found,† part of a string of ornaments such as commonly are worn by savages. Of these I give examples: one a boar's tusk, from the lake dwellings of Switzerland; another, a tooth from a deposit of palæolithic age, in a cave just above the miraculous grotto of Lourdes in the Pyrenees. I have examined fragments of bone and teeth [from the Crag] of various sizes and shapes, and found them marked over the surface with many a pit or deeper hole, or even perforation irregularly placed, not as if by design, but accident. There they were in every stage, all over, yet of one type. One sawn across explains the whole. The chamber of a shell which bores its way into the solid rock or softer shale was clearly shown. When the mass lay embedded in the mud it was but touched here and there. If it was thin the animal bored through into the sand or clay below, piercing the tooth quite through—a perfectly well-turned and finished work, so good it was thought to be man's. But if the mass was thick and near the surface, the little mollusk made a home entirely within it, and its shell often remains there, and reveals the history and manner of formation of the holes.

An account has also been given by the Abbé Bourgeois of flints from Pliocene beds at St. Prest, near to Chartres, said to be

* Journ. Anthrop. Inst., vol. iii, p. 127, April, 1873.
† Journ. Anthrop. Inst., vol. ii, p. 91, April, 1872.

worked by man, but this we may dismiss on the same ground as those before referred to given on the same authority.*

Another case brought forward from abroad but recently, has found much favor here as there.† Around the Lake of Zurich there are left traces of ancient lakes at somewhat higher levels. A bed of clay below with glacial stones, a bed of plants between half-turned to coal, a mass of clay moraine-like on the top, tell of the time when Alpine ice crept farther down the hills, and touched upon the lake, now more, now less encroaching. In these beds the peaty mass of lignite, known as Dürnten coal, was largely dug for fuel. I have worked a long time down below to see the evidence myself. The sequence of the beds is clear. But recently two Swiss professors have proclaimed that they have obtained proofs incontestable that man was there, and wove a basket, fragments of which were found among the drifted plants which formed the coal. These fragments, it is said, consist of pointed sticks, sharpened across the grain, not tapering naturally, and a cross set of binding withes, all now pressed and changed, but by such characters referred to work of man. Now I have found myself along the shore fragments of wood and twigs half decomposed and waveworn till they were cut to a point obliquely to the grain, as they describe the Dürnten sticks. Across such fragments often others fell, and when the whole was then compressed what wonder if they left a mark of wattle or of basket-work? and the whole mass has suffered such great pressure from the superincumbent weight of clay that all the round twigs and stems are squeezed quite flat, as in the specimens before you. These Dürnten pointed sticks, however, I have not seen, and, therefore, speak with caution, showing only how I think the thing might be otherwise explained.

Widespread beds of loam and sand, and gravel, cover the lower levels of East Anglia; and, probably ranging over a vast period, have been collectively described as "middle-glacial," for below are glacial beds, and in the middle series bowlder clay, and over them, whether in part *remanié* or not, another bowlder clay. Lying in hollows and on the flanks of valleys, cut through this ancient loam and other beds, are river terraces of later date; and these, because in great part made up of the older beds, are like them, and require experience to distinguish. In these old terrace-deposits implements of man's undoubted work have long been found; but recently it has been said that some of these beds belong to the older series.‡ This, then, becomes a matter of opinion. For my part, being well acquainted with the deposits in question, and having listened to the evidence, I give my testimony quite against the Glacial or the inter-Glacial age of any of the beds from which the hatchets came. It is, however, said that

* Bourgeois, Congr. Inter. d'Anthrop., 1867, p. 67.

† Rütimeyer, Archiv. für Anthropologie, 1875; Heer. Primæval World of Switzerland.

‡ Mem. Geol. Surv. Geology of Fenland.

other evidence has since been found, conclusive as to this. I can but criticise that which has been adduced; but I will say that if such has been found and been so long withheld, while there are so many deeply interested, and so many who would like to verify at once and on the ground the statements made, then I do hold that there has not been shown that love of full investigation which is the soul of science.

In many countries where rocks of limestone tower in cliffs and crags above the valleys, and are tapped below by undermining streams, the rain which falls upon the higher ground is lost in cracks and joints, and carries off the rock dissolved in water, which contains a little acid caught by the falling rain or drawn from decomposing plants. The fissures thus enlarged into the gaping chasms called "swallows' holes," the "katabothra" of the Greeks, admit a copious torrent, carrying stones and sand which grind and bruise and open out the jointed rocks into great caves and subterranean courses. These, when tapped at lower levels, are soon left dry, and offer to prowling beasts of prey a safe retreat, and often man availed himself of them, as testify the Adullamites and Troglodytes of every age.

From such a cave up in the crags of Craven some evidence is adduced that man existed far back into Glacial times, and this, perhaps, is the best case that has been urged.* There a large group of animals, such as occur elsewhere along with man, and more doubtfully traces of man himself, were found in beds overlapped by Glacial clay which had sealed up the mouth of the vast den in which these relics lay. This excavation I have watched myself at intervals from the commencement, and I hold that as the cliff fell back by wet or frost, and limestone fragments fell over the cave mouth, with them came also masses of clay, which, since the Glacial times, had laid in hollows in the rock above. We dug and found such there, and, more, I observed that the clay lay across the mouth as though it had thus fallen, and not as if it came direct from Glacial ice that pushed its way athwart the crag in which the cave occurs. It seemed to have fallen obliquely from the side where the fissured rock more readily yielded to the atmospheric waste, so that it somewhat underlay the part immediately above the cave. On the inside the muddy water which collected after flood, held back by all this clay, filled every crevice and the intervals between the fallen limestone rock, while still outside was the open *talus* of angular fragments known as "screes."

These are the most important cases that I know where man has been referred to Glacial or inter-Glacial times; but all, it seems to me, quite inconclusive. On the contrary, there is much in them, and much besides pointing the other way. In support of which opinion I will now offer some independent evidence, showing that some similar beds with man and the beasts that are found with him in earliest times can be proved to be post-Glacial. * * *

* Tiddeman, Brit. Assoc. Reports, 1870–8.

Remarks on the paper of Professor Hughes by Professor W. Boyd Dawkins, F.R.S.—I entirely hold with Professor Hughes in the view which he takes relating to the antiquity of man, and the necessity of looking narrowly into facts bearing on the question. All the alleged cases of the existence of man before the Palæolithic age, on the Continent, seem to me on a careful inquiry to be unsatisfactory. If the flints found at Thenay, and supposed to prove the existence of Miocene man, be artificial, and be derived from a Miocene stratum, there is, to my mind, an insuperable difficulty in holding them to be the handiwork of man. Seeing that no existing species of quadruped was then alive, it is to me perfectly incredible that man, the most highly specialized of all, should have been living at that time. The flints shown in Paris by Professor Gaudry appear to be artificial; while those in the Museum of St. Germains appear to be partly artificial and partly natural, some of the former, from their condition, having been obviously picked up on the surface of the ground. The cuts on the Miocene fossil bones discovered in several other localities in France may have been produced by other agencies than the hand of man.

Nor in the succeeding Pliocene age is the evidence more convincing. The human skull found in a railway cutting at Olmo, in Northern Italy, and supposed to be of Pliocene age, was associated with an implement, according to Dr. John Evans, of Neolithic age. Some of the cut fossil bones discovered in various parts of Lombardy, and considered by Professor Capellini to be Pliocene, are undoubtedly produced by a cutting implement before they became mineralized, a point on which the examination of the specimens leaves me no reason for doubt. I do not, however, feel satisfied that the bones became mineralized in the Pliocene age; and the fact, that only two species of quadruped now alive then dwelt in Europe, renders it highly improbable that man was living at this time. This zoological difficulty seems to me insuperable.

The only other case which demands notice is that which is taken to establish the fact that man was living in the Inter-glacial age, in Switzerland. The specimens supposed to offer ground for this hypothesis consist of a few pointed sticks in Professor Rütimeyer's collection at Basle, of the shape and size of a rather thin cigar, crossed by a series of fibers running at right angles. They appear to me after a careful examination to present no mark of the hand of man, and to be merely the resinous knots which have dropped out of a rotten pine trunk, and survived the destruction of the rest of the tree. As the evidence stands at present, there is no proof, on the Continent or in this country, of man having lived in this part of the world before the middle stage of the Pleistocene age, when most of the existing mammalia were alive, and when mammoths, rhinoceroses, bisons, horses and Irish elks, lions, hyænas, and bears haunted the neighborhood of London, and were swept down by the floods of the Thames as far as Erith and Crayford.

2. *On the Age of the Brazilian Gneiss Series. Discovery of Eozoon;* by ORVILLE A. DERBY, M.S., Rio de Janeiro.—The late Professor Hartt has shown in his work entitled "the Geology and Physical Geography of Brazil," that the whole Brazilian plateau is either composed of, or underlaid by, gneissic rocks, which appear at the surface, forming one or more great mountain chains along the whole Atlantic coast, from the Province of Rio Grande do Sul, to Maranhão. In the provinces of São Paulo, Rio de Janeiro, and Minas Geraes, this series forms two detached and parallel chains, separated by the valley of the Parahyba river, and known as the Serra do Mar and Serra da Mantiqueira, which rise to the height of 6,000 feet or more, the latter range being somewhat the higher, the culminating point and highest mountain in Brazil, the Pico de Itatiaia, having a height of 8875 feet. The Serra do Mar, as represented in the Organ Mountains, at Heresopolis, is, according to Professor Agassiz, a sharp anticlinal ridge, the almost vertical beds dipping on each side of the center of the range, an observation which has since been verified by Professor Hartt and myself. Farther west, where crossed by the Dom Pedro II Railroad the same Serra is described by Prof. Hartt as a monoclinal ridge, the beds dipping at a high angle to the northward or toward the Parahyba, there being most probably some repetition in the beds, owing to reversed folds or faults. The Mantiqueira range, according to Professor Hartt's observations at Itatiaia, and my own along the railroad near Barbacena, in Minas Geraes, is also a monoclinal ridge, the beds dipping at a less angle than in the Serra do Mar to the southward or toward the Parahyba. The valley of this river appears, therefore, to be a great synclinal.

The succession of the Brazilian gneisses is, according to the observations of Pissis, Hartt, Liais and myself, (1) Porphyritic or granitic gneiss, with red feldspar; (2) fine-grained gray gneiss, (leptinite of Pissis and Liais), often garnetiferous and schistose; (3) fine-grained schistose gneiss, passing to mica schist, with subordinate beds of quartzite, and an abundance of mineral veins not found in the lower parts of the series. This last, the upper or metalliferous series of Pissis and Liais, prevails in the Mantiqueira range, while the lower divisions predominate in the Serra do Mar and Parahyba valley.

The gneiss series was referred by Professor Hartt to the Archæan, on account of its position beneath the other Brazilian strata, and the striking resemblance with the Laurentian series of North America, this opinion being confirmed by Dr. Sterry Hunt from an examination of the specimens collected by Professor Hartt. At that time no fossiliferous rocks older than the Cretaceous were positively known in the empire. Since then, however, the labors of the members of the Geological Commission have shown that the coal-bearing beds of southern Brazil belong, as was at first supposed, to the Carboniferous, and are underlaid, in the province of Paraná, by beds of Devonian or Upper Silurian age;

and that, on the Amazonas, there is a fossiliferous series consisting of Carboniferous, Devonian and Upper Silurian, resting, unconformably, not on the gneiss, but on an extensive series of quartzites superior to it.

In southern Brazil, at least, limestones are extremely rare in the gneiss series. The only bed definitely known is a thin one in the Parahyba valley, well exposed at the Barra do Pirahy, where it was examined by Professor Hartt and myself. The river, both above and below Barra, flows along the strike of the beds, which is very regularly N. 60° E., the limestone appearing at various points, at, or near the river, until it makes a bend to the eastward and escapes from behind the Serra do Mar, above the city of Campos. This distance is about 120 miles. About 30 miles above Barra, along the line of strike, limestone is reported near Barra Mansa.

It is remarkable that about 100 miles farther to the southwestward, limestone in the gneiss series is reported by Rath near Gnape, in a locality which is almost exactly on the prolongation of the line of strike from Barra.

The bed at Barra is about fifty feet thick, enclosed in schistose, garnetiferous gneiss, and dips 60′ to the northward.

The rock is a coarsely crystalline, white marble, showing a beautiful bluish tint when held to the light in thin pieces, and contains a small amount of pale green serpentine, soft and greasy like talc, from decomposition, distributed in thin films along the planes of bedding. The serpentine is not distributed through the mass and nothing resembling Eozoon is to be found. Near the small village of Sta Anna de Pirapitinga, the farthest point to the northeast of Barra, where the limestone is known, I have lately had an opportunity of examining it, through the kindness of my friend, Dr. J. A. de Santos, who called my attention to it. The bed here has almost precisely the same thickness, position and lithological characters as at Barra, and, being on the line of strike of the bed at the latter place, with a number of known localities at intervening points, on or near the same line, where similar rock occurs, I have no doubt of the identity of the bed. The surfaces exposed in the quarry are covered with beautiful foliaceous incrustations of chalcedony, and the small admixture of serpentine, instead of occurring in films, as at Barra, is thickly distributed in small points throughout limited portions of the bed. Specimens of this rock polished and treated with acid, present various appearances described by Dr. Dawson as characteristic of Eozoon.

Note.—Since writing the above, Mr. Derby, in the course of explorations along the Rio Sao Francisco, has discovered a bed of serpentine limestone, in the metamorphic series of the Serra da Caraunã, Province of Alagoas, near the falls of Paulo Affonso, which, he says, is very similar in character to that of the Barra do Pirahy and Pirapitinga. A single small fragment of the Pirapitinga limestone, and several larger ones from the beds at Caraunã, sent me by Mr. Derby, have been examined by Dr.

Dawson, of Montreal, who kindly furnishes for publication, the following notice regarding their organic contents.—R. RATHBUN.

3. *Note on Limestone from the Gneiss Formation of Brazil;* by J. W. DAWSON, LL.D., F.R.S.—The specimens submitted to me by Mr. R. Rathbun, from the collection of Mr. Derby, are as follows:—

No. 1. Small specimen, which has been etched with acid, and is stated to be from Sta. Anna de Pirapitinga. This specimen consists of dolomite and calcite, white and crystalline, with grains of olive-colored serpentine. It shows some obscure forms which may be organic; but nothing which can be affirmed to be *Eozoon.* The specimen is, however, too small and imperfect to afford any definite information as to its nature and fossil contents.

No. 2. This is a limestone apparently similar to the last, and presumably from the same formation. It is said to be from the Serra da Caraunâ, Province of Alagôas. As there were several small fragments of this limestone, it was carefully etched with dilute nitric acid. On examination it showed in a few spots groups of canals similar to those of *Eozoon Canadense,* filled with dolomite. These probably represent fragments of *Eozoon.* There is no appearance of lamination, and the rock seems to consist of limestone and dolomite intermixed, and with grains of pale olive serpentine. The rock and its contained fragments of *Eozoon* resemble those of some layers of the limestone of Petite Nation, and also the limestones of Chelmsford, Massachusetts, and of Warren county, New York. I have no doubt that this limestone is of Laurentian age, and partly composed of fragments of *Eozoon,* and think it probable that more extended search may discover in it entire masses of the fossil.

4. *Geological Survey of Alabama; Report of progress for* 1877 *and* 1878; by EUGENE A. SMITH, Ph.D., State Geologist. 140 pp. 8vo. Montgomery, Alabama, 1879.—Dr. Smith commences his valuable Report, with a general sketch of the features and geology of the Basin of the Tennessee, in Northern Alabama, where the coal-measures are the uppermost beds, with the exception of the stratified drift of the valleys. Then follow chapters on the Geology of the Counties which belong to the Tennessee Basin; an account of Brown's Valley, which covers parts of Jackson, Marshall, Cullman and Blount Counties, and geological descriptions of parts of the Warrior Coal-field Basin. The Warrior Coal-field Basin is a southwestern portion of the Cumberland Table-land, so conspicuous a feature in the eastern half of Tennessee. In this basin in Jefferson County, along a ridge in Jones' Valley, dividing it longitudinally, there occurs one of the great faults of the Appalachians, so well marked at the east foot of the Cumberland Tableland in Tennessee. The strata of the Upper Silurian, Devonian and Sub-carboniferous, are brought up by it to a level with a limestone of the Quebec group, and, besides, there is an overturn, the last-mentioned formation overlying, with conformable eastward dip, all the other formations, with the Sub-carboniferous beds

the lowermost. The geology of several of the valleys is illustrated by maps. It closes with a Chemical Report by HENRY MCCALLY, of the University of Alabama, giving analyses of coals and iron ores, and a list of Elevations (with their distances from Memphis), on the Memphis and Charleston railroad.

5. *On Conodonts from the Chazy and Cincinnati Group of the Cambro-Silurian, and from the Hamilton and Genesee-Shale Divisions of the Devonian, in Canada and the United States;* by GEORGE JENNINGS HYDE, Esq., F.G.S., with three plates.—From this interesting monograph, we quote the following clause, giving the general results arrived at:

It has been shown that whilst Conodont teeth do not correspond in minute structure with, and are far more varied in form than, the teeth of any known fish, they yet approach closest to those of the Myxinoids. As it is not at all improbable that there was in Palæozoic times as great a development of the Cyclostome Fishes as of the Ganoids and Elasmobranchs, with a consequent great amount of variation in their structural development, we could hardly judge, from their pauperized descendants of the present day, how far this variation may have extended in former times. We should not, therefore, on account of the imperfect analogy of the Conodonts with the teeth of existing Myxinoids, reject altogether the probability that they may have belonged to a similar low type of Fishes. At present, however, the facts at hand appear insufficient to decide the question.—*Quarterly Journal of the Geol. Society*, Aug., 1879.

6. *Report on the Paleontological Field-work for the season of* 1877; by C. A. WHITE, M.D. (Extracted from the 11th Annual Rep. U. S. Geol. Survey, F. V. Hayden, Geologist-in-charge).—Professor White gives in this Report large additions to the known facts respecting the distribution of fossils of the Fox Hill group of the Upper Cretaceous, and the Laramie (or Lignitic) Group. With regard to the former he gives, in his concluding chapter, tables illustrating the range of the species under columns, headed (1) Upper Missouri region, (2) Eastern Colorado, (3) Northwest Colorado, (4) Coalville in Utah, (and the whole valley of Weber River), (6) Bear River Valley (including also the adjacent portion of Sulphur Creek up to Hilliard Station). A similar table for the Laramie group has for its columns (1) Judith River Beds, (2) Fort Union Beds, (3) Eastern Colorado, (4) Northwest Colorado, (5) Bitter Creek Valley, (6) Bear River Valley. Professor White concludes that the waters of the great Laramie sea were essentially brackish, and that the commingling of fresh water and brackish water species did not arise from fluvial transportation but from their having lived and thrived together.

7. *Cretaceous Fossils of the Western States and Territories*, by C. A. WHITE, M.D. *Contributions to Paleontology.* No. I. (From the 11th Annual Rep. Surv. for 1877, U. S. Geol. Surv., F. V. HAYDEN, Geologist-in-charge).—This Report contains, besides descriptions of numerous species, also many figures of the species on ten plates.

8. *Remarks on the Genus Proterocrinus* of Lyon and Casseday, by A. C. Wetherby. Journ. Cincinnati Soc. Nat. Hist., April, 1879.

9. *Revision of the Palæocrinoidea.* Part I. *The families Ichthyocrinidæ and Cyathocrinidæ;* by Charles Wachsmuth and Frank Springer. 153 pp. 8vo, with two plates. Philadelphia, 1879 (from the Proceedings of the Academy of Natural Sciences, Nov. 4, 1879).—A very important contribution to the department of Fossil Crinoids.

10. *Descriptions of New Species of Crinoids from the Kaskaskia Group of the Subcarboniferous;* by A. C. Wetherby. Ibid., October, 1879.—Professor Wetherby, in these papers, describes in detail from excellent specimens the genus Proterocrinus, and several species of the remarkable crinoids referred to it. The author states that the *Dichocrinus cornigerus* and *D. 6-lobatus* of Shumard cannot be referred to the genus as has been proposed, and that its nearest alliance is with *Eucalyptocrinus.* Four species, *P. bifurcatus*, *P. acutus*, *P. spatulatus* and *P. parvus* are beautifully figured on one of the plates.

III. Botany and Zoology.

1. *Soluble Matter of Soil retained by Vegetation.*—**Soil three inches deep was placed in two glazed earthenware pans, 17 inches in diameter, on July 21: four grams of white clover seed was** sown in one, the other being blank. The pans were exposed till Oct. 4. The drainage water was collected and analyzed; that from the clover soil contained 48·1 grains of solid matter per gallon; the other 220. The author concludes that rain removes much more matter from an uncropped than from a cropped soil.—*Chem. Soc.*, Jan. 15; from *Nature*, Jan. 22.

2. *Seeds endure extreme Cold.*—Casimir DeCandolle and Raoul Pictet, of Geneva, have continued and extended some old experiments upon this subject, the results of which are reported in the Arch. Sci. Phys. & Nat. for Nov. 1879. Seeds of mustard, cabbage, and grains of wheat, without previous desiccation, enclosed in sealed tubes, sometimes mixed with metal filings to ensure complete and rapid refrigeration, were exposed to a temperature of from −50° to −80° centigrade, for from two to six hours, the cold produced by the evaporation of liquid sulphurous acid; the seeds were allowed to regain the ordinary temperature of the air without delay; then, on being sown, they germinated as promptly and well as corresponding seeds not so treated. A. G.

3. *The Genus Ginkgo*, now represented by the single Japanese species, first appears (according to Heer, in Arch. Sci. Phys. & Nat., Dec. 1879), in a single species, in a deposit between the Jurassic and Triassic, and in the Jurassic counted nine species, two of which extended from England to Spitzbergen, while the other seven along with one of the former inhabited eastern

Siberia, one of them reaching Japan, the present home of all that survives of the genus. One or two species are known in the Wealden, and two others in the Tertiary. One of these, known from northern Greenland and from Sachalin, is so near the extant species that it may be united with it. In the Jurassic this genus was accompanied by four other Taxineous genera, one of which (*Baiera*) was continued into the Cretaceous formation; in the Tertiary also by another (*Feildenia*), recently discovered by Nordenskiöld in Spitzbergen. *Cordaites* carries the Taxineous type back to the Carboniferous and the Devonian; so that this group of plants contains the most ancient Phænogams. A. G.

4. *The Floral Development of Helianthus annuus*, by W. H. GILBREST.—A paper in the Journal of the Quekett Microscopical Club (Oct., 1878), with a plate. The two points of interest relate to the morphological nature of the pappus and of the ovule. The latter develops as if it was the termination of the axis. The two scales of the former, both as to development and structure, should be regarded as foliar (not trichomes), and therefore as answering to calyx; but their development is much later than that of the corolla. The paper is a neat one. A. G.

5. *Morphology of Vegetable Tissues*, by W. H. GILBREST.—A paper reprinted from the Journal of the Royal Microscopical Society, read Oct. 8, 1879, with two plates, treating the histology of the Cambium, in several Dictyledonous trees and shrubs; summed up by the author thus:

. . . . "It appears that the cambium layer is not a portion of the procambium remaining over after the differentiation of the primary phlœm and xylem, but a special and new tissue developed from it. . . . . That the cambium is composed of prosenchymatous cell-groups; . . . . on the phlœm side parenchyma is produced by the rounding off and sometimes by the further division of the individual cells, and prosenchyma on the xylem side by the absorption of the transverse septa; wood-parenchyma being simply those cambium cell-groups in which such absorption has not taken place. That the vessels arise by fusion of certain cambium cell-groups, which are arranged vertically, and the oblique septa separating the groups being partly absorbed, and the transverse ones entirely so. That absorption of the oblique septa appears to commence with the formation of sieve-plates, the pores of which enlarge and coalesce till there is either one large circular aperture through the center, or the bands dividing the sieve-plates remain, forming the scalariform septa of some species." A. G.

6. *Aroideæ Maximilianæ, die auf der Reise Sr. Majestät des Kaisers Maximilian I, nach Brasilien gesammelten Arongerwächse nach handschriftlichen Aufzeichnungen von H. Schott beschrieben von* Dr. J. PEYRITSCH. (Wien: Gerold's Sohn, 1879.) —This is an imperial folio volume, sumptuously illustrated with forty-two plates of new *Aroideæ*, and a frontispiece of Aroideous Vegetation, done in chromolithography. It is the best chromo-

lithography we have seen. The copious details, most admirably drawn, are also printed in colors and are very effective. The letter-press is equally superb. It was in part prepared by Schott, the first monographer of the *Aroideæ*, who died in 1865, was then taken in hand by Kotschy, who died soon after, and by Fenzl, whom we have recently lost, and is now completed by Dr. Peyritsch. This magnificent book is the latest and probably the last of the fruits of the voyage to Brazil (in 1859–60) of the unfortunate Maximilian. We suppose it is brought out by his executors, and is a monument to his memory. A. G.

7. *Naturalized Weeds and other Plants of South Australia*, by RICHARD SCHOMBURGK, Ph.D., etc. Adelaide, 1879. 4to pamphlet.—It was a good thought to make a record of the troublesome plants already naturalized in South Australia, with as far as possible the dates and particular circumstances of their introduction, and thus to give succeeding observers the means of comparing the future with the present condition. It will be interesting to know whether the species most aggressive up to this time will continue predominant, or whether they may either lose their exceptional vigor or be checked at length by other competitors. The race is not always to the swift, if it be a long one. Most of the introduced weeds came from Europe. The following are exceptions:

Oxalis cernua of the Cape of Good Hope. This arrived as a garden plant, near the year 1840; it now overruns all gardens, and is spreading most alarmingly in the wheat fields. It is said that the first bulbs were sold for two pence each. It now has notorious preëminence over all introduced weeds, since it is next to impossible to eradicate it when it has obtained a footing.

Cryptostemma calendulacea, called Cape Dandelion, "has taken possession of the land for the last twenty-five years, and grows as vigorously as ever," covering even the mountain ranges, when untimbered, to their summits. It is an annual, and is much liked by cattle and sheep, so that it is not so much of a nuisance.

The next are mostly common weeds of Southern Europe, but many of them came in by way of Tasmania. The worst are *Compositæ*, and are mainly Cockspur or *Centaurea Melitensis*, Bathurst Bur or *Xanthium spinosum*, Scotch Thistle or *Onopordon Acanthium*, and *Inula suaveolens*, called Stink-Aster, "the most noxious and dangerous plant ever introduced." An equally bad character is given to the Black Oat, *Avena sativa*, var. *melanosperma*, which is singular, considering that its near relative, the *Avena sterilis*, is a great blessing to California, over which it has been widely diffused. Dr. Schomburgk says: "The Black Oat has the most notorious preëminence of all the introduced weeds, and the effects of this intruder are most ruinous to the farming community. . . . . Thousands of acres of arable land, especially such as have been in cultivation for some years, are totally ruined for the purpose of wheat-growing by the black oats."

A dozen and a half of other grasses which occur in the list "are less dangerous to cultivation, in fact they have improved the native pasture near the coast materially," and the same is said of the *Leguminosæ*, which are Clovers, Melilots, and Vetches.

A glance at the list of weeds throughout does not favor the idea that they owe their predominance in any perceptible degree to self-fertilization. *Oxalis cernua* propagates by its bulbs, and so may be ranked with self-fertilized plants by analogy; but the blossoms have provision for cross-fertilization. All except the grasses and four or five Dicotyledons are coroliferous, and most of them insect-visited. A. G.

8. *Canadian Timber-trees, their Distribution and Preservation;* by A. T. DRUMMOND.—An instructive pamphlet, published at Montreal in 1879, being a Report to the Montreal Horticultural Society, accompanied by a map (by Dr. Bell and Mr. Drummond) marking the northern limit of the principal forest trees of Canada and Nova Scotia. There are sixty-five species of trees in this district; but only the most important ones are specified. More stringent laws are recommended for the prevention of forest fires, which in Canada, as elsewhere, are the crying evil. The fact that the jutting headlands of Lake Superior have a semi-arctic vegetation, while the bordering district to the northward has the common cool temperate flora, is alluded to. It is attributed to the moist, cool, but equable atmosphere, resulting from the presence of such a large body of deep water, retaining here the vegetation of an older and cooler period. But the sweep of winds, keeping back the forest, may also be considered. A. G.

9. *Indian Corn;* by E. LEWIS STURTEVANT, M.D. A paper presented to the Annual meeting of the New York State Agricultural Society, January 1879, and reprinted from its 38th Annual Report.—The history of Maize is detailed with considerable fulness, and the opinion is hazarded that the plant may have reached Europe by grain brought by the Northmen in the eleventh century, and by them have been transferred to the Levant. But there seems to be no proof that the plant had reached Turkey before the time of Columbus. The principal varieties of Indian cultivation are enumerated and the variations of ordinary cultivation are classified. The number of rows of grain on the cob vary from 8 to 36, and nearly all are in even number of rows; but odd numbers are not uncommon and perhaps prevalent in the maize of the Incas or of earlier South American races, preserved with mummied Indians. A section of Hybridizing adduces original observations in confirmation of the action of the pollen of one variety in directly altering the grain of another; and this influence is said to affect not only the coats of the grain but the nature and appearance of the kernel. A. G.

10. *Death of General Munro.*—With sadness we hear that Gen. Wm. Munro, of the British army, the most accomplished Agrostologist of our day, died at his residence near Taunton, on the 29th day of January. He had reached the age of about 64 years, and

of late his health had deteriorated to an extent that gave his friends concern. But it was thought his valuable life might be prolonged so that he could achieve the great work upon which his heart was set and the hopes of botanists centered, viz., the *Species Graminum*. Although until recently his studies in botany were pursued in the precarious intervals of an active professional life, necessitating frequent changes of abode under widely different climates, he had mastered his favorite department, so that no one living knew grasses so well, or was so competent to treat the whole order systematically. Of independent publication he had done little, except to bring out a monograph of the bamboo tribe, which shows what he was capable of. But upon the retirement from active service, with honors well earned by arduous and splendid service, he devoted the remainder of his life to a revision of all grasses, which was to form two volumes of DeCandolle's *Monographiæ Phenogamarum*. Alas, it was too late. But perhaps the monograph of the *Paniceæ* may have been nearly completed. Yet the great *desideratum* of botanists remains, and their hopes are dashed on the eve of expected fulfillment. Personally, Gen. Munro was greatly respected, trusted, and beloved. The very distinct genus which commemorates his botanical services, *Munroa squarrosa* of Torrey, is one of the Buffalo grasses of our western plains.* A. G.

11. *Crustacea of Mexico and Central America.*—Mission Scientifique au Mexique et dans l'Amérique Centrale, publié par ordre du Ministre de l'Instruction Publique. *Études sur les Xiphosures et les Crustacés de la Région Mexicaine*, par M. ALPHONSE MILNE EDWARDS. 4to, Paris: 4ᵉ livraison, pp. 121–184, 9 plates, 1878; 5ᵉ et 6ᵉ livraisons, pp. 185–264, 19 plates, 1879.—The earlier parts of this magnificent work were noticed in vol. xi of this Journal (p. 329, 1876). In the last three parts the account of the Maioidea is completed and that of the Cancroidia begun; the fourth part contains the last of the Mithracinæ, the Micippinæ, Libininæ, Amathinæ, Epialtinæ, Parthenopinæ (including *Œthra*) and part of the Leptopodinæ; the fifth part completes the last family and, with a short supplement, the Maioidea, and begins the Portuniens, which are completed and the Cancerieus well begun in the sixth part. Though, upon the groups of which it treats, already by far the most extensive and important work appearing within twenty years, it seems thus far to have escaped notice in the Zoological Record. It deserves a more extended notice than the space at my disposal in these pages permits.

The nine families of Oxyrhynques (Maioidea) include 58 genera and 150 species; 11 of the genera and 30 of the species are new, and over 80 of the species are figured. The Portuniens include 9 genera and 28 species, 1 genus and 3 species being new, and half the species are figured. The generic grouping of the Portu-

* Published in the fourth volume of the U. S. Pacific Railway Expedition Reports; erroneously printed *Monroa*. There is also a mistake in saying that Col. Munro was in the East India Company's service, though he served long and bravely in India.

ɜ is considerably modified from that adopted by the same au- · in his monograph of the group published in 1861, so that the ɜra are nearly the same as used by Stimpson. *Callinectes* is ıitted but all the forms described by Ordway are reduced to eties of a single species and a number of new varieties are ꞉ribed. The old name *diacanthus* is restored for the polymor- ꞉ species thus constituted, but the varietal names are printed he same way as the specific, so that under the species "*Cal- ctes diacanthus*" we have the variety "*Callinectes diacanthus* dway)," which is certainly confusing. *Cronius* is adopted, *Arenæus* is still retained under *Neptunus*. The Canceriens 'ar as treated include 13 genera and 29 species; 2 genera and ıecies are new, and 19 species are figured.

'he plates are admirable and are crowded with most excellent res, of which several are usually given for each species. Some he plates on which the larger of the species are represented lithographic and two of these in the sixth part are colored, but great majority of the plates are engraved in the finest manner netal. S. I. SMITH.

2. *U. S. Commission of Fish and Fisheries. Report of the nmission for* 1877. Part V. Washington, 1879. 8vo. 981 numerous plates.—This volume includes in the general report Professor S. F. Baird, the Commissioner, a statement of the ılts accomplished both in the way of exploration and in the pagation and introduction of food-fishes, and the participation he Commission in the Fishery Convention at Halifax. Several ıdred pages are occupied by a thorough history of the men- .en and the fisheries and manufactories dependent upon it, by G. Brown Goode. Among the other papers is one by Karl nbeck, on the distribution of the cod family; on the cod fish- s near the Loffoden Islands, by G. O. Sars; on the salt water eries of Norway, by G. O. Sars; several reports on the arti- ıl propagation of various fishes; on the Miller Cassella ther- neter, by Commander L. A. Beardslee; on artificial refrigera- ı, by John Gamgee. V.

3. *American Fisheries. A History of the Menhaden, by* G. ɔWN GOODE, *with an account of the Agricultural Uses of Fish;* W. O. ATWATER. 8vo. 529 pp., 30 plates. New York: ınge Judd Company, 1880.—This is a separate edition of Mr. ɔde's report, included in the preceding, with additions bringing subject down to date. V.

4. *The Chinch Bug (Blissus Leucopterus): Its history, charac- and habits and the means of destroying it or counteracting its ıries;* by CYRUS THOMAS, Ph.D. With a map showing the ;ribution. 44 pp. Washington, 1879 (U. S. Entomological nmission, Bulletin No. 5).

IV. Miscellaneous Scientific Intelligence.

1. *Vesuvius.*—In Nature (xxi, p. 351), Mr. G. F. Rodwell summarizes the history of the volcanic action of Vesuvius in the last year. During 1879, small streams of lava appeared at intervals on the sides of the great cone, and on December 17, a stream reached to the Atrio del Cavallo. On January 13, 1880, he ascended the cone, although with difficulty on account of the violent and cold wind which prevailed. The small inner cone had increased since his ascent of the previous year, and now reached more than fifty feet above the rim of the great crater, which moreover was almost filled up by lava and scoriæ.

The cone of November, 1878, was giving off dense volumes of steam and smoke and seemed to be full of lava. Near its base was an opening, "apparently about five feet in diameter," through which there had been recent outflows, and while he was watching it, a stream of lava issued forth, which soon after flowed over the rim of the great crater in a stream 25 feet wide, and before next morning had reached the same extent as on December 17. A private letter from a gentleman, who ascended to the lip of the crater on February 2, speaks of a small eruption two days before, which had filled the crater and overflowed exactly in the direction of the top of the railroad which is being constructed up the cone, and nearly reached the place staked out for the station. From the lower part of this stream the lava was still advancing at the rate of about a foot a minute. In regard to the future, Professor Palmieri says, "This long and mild eruptive period will not in our opinion come to an end without displaying more decided activity. The whole history of Vesuvius may be divided into periods of activity, with occasional phases of violence, and short intervals of rest. And the greatest eruptions have generally indicated the last phase of long periods of moderate activity." C. G. R.

2. *The Study of Earthquakes in Switzerland.*—The Commission on this subject, appointed at the meeting of Swiss Naturalists in 1878, consisting of Professor Foster of Bern as President, Professor A. Heim of Zurich, Secretary, with Professors Amsler, Forel, Hagenbach and Soret, and M. Biswiller, has perfected a schedule of operations. It is proposed to provide two or three chief stations (Bern, Basel, and if possible Geneva) with first-class seismometers, and then to organize a wide set of second-class stations with simpler instruments. For the latter there are three propositions, two being modifications of the pendulum and mercury seismometers, and the third, essentially the row of graduated cylinders suggested by Mallet. They are to be submitted to experiment to determine the most desirable. Besides this, as tending to interest the public in such observations, Professor Heim has published a pamphlet on the nature and causes of earthquakes, and on the means of observing them without instruments. This pamphlet, which will be translated into French, is to be widely distributed.

Further, the whole country is divided into seven regions, one being assigned to each member of the Commission, who, on the occurrence of an earthquake in his section, will at once send printed lists of questions in regard to it to all persons likely to give information. The replies will of course become matter of record. If this well-laid plan is carried out, it is likely to afford extensive and valuable information in regard to Swiss earthquakes, and to aid greatly in the general study of the subject.—*Abstract from Nature.* C. G. R.

3. *On the Figure of the Earth.*—In a paper by Colonel A. R. CLARKE on the figure of the earth, published in the Philosophical Magazine, for January, 1878 (p. 81), the following values are given for the dimensions of the terrestrial ellipsoid:—

$a=20926629$ feet. $b=20925105$ feet. $c=20854477$ feet.

Here a and b are the equatorial radii, and c the polar radius.

The ellipticities of the two principal meridians of the earth (i. e. the ratio of the difference of the semi-axes to half their sum) are:— $\frac{1}{289 \cdot 54}$ and $\frac{1}{295 \cdot 77}$.

Col. Clarke adds:—"The longitude of the greater axis of the equator is 8° 15′ west of Greenwich, a meridian passing through Ireland and Portugal, and cutting off a portion of the northwest corner of Africa; in the opposite hemisphere this meridian cuts off the northeastern corner of Asia, and passes through the southern island of New Zealand. The meridian containing the smaller diameter of the equator passes through Ceylon, on the one side of the earth and bisects North America on the other. This position of the axis, brought out by a very lengthened calculation, certainly agrees very remarkably with the distribution of land and water on its surface."

The values of Listing corresponding to the above, quoted from the Astronomische Nachrichten in this Journal, vol. xvii, p. 74, Jan., 1879) (employed by Todd, l. c. xix, 62, Jan., 1880), are not well founded and should not be accepted.

4. *Metallurgy: the art of extracting metals from their ores;* by JOHN PERCY, M.D., F.R.S., etc. *Silver and Gold.* Part I. 698 pp. 8vo. London, 1880 (J. Murray).—This is the first part of the fifth of the series of volumes upon metallurgy by Dr. Percy. These volumes form distinct, and in a measure, independent treatises. The present volume shows the same careful and scholarly treatment that has characterized the previous works by this author. It contains a chapter of over two hundred pages on the physical and chemical properties of silver and its alloys, with a description of all the known minerals containing silver. This is followed by a very complete account of the methods and apparatus used in the assaying of silver (75 pages); the separation of silver from copper by the liquation process (195 pages); smelting of ores containing silver chiefly in the metallic state and the combined silver and lead smelting (52 pages); concluding with amalgamation, or the extraction of silver from its ores by means of mercury

(104 pages). This last section covers only the Mexican or *patio* process as practised in Mexico and South America. The second part of this volume, a portion of which is already in type, will be awaited with interest, as it will contain a discussion of the pan-amalgamation as practised in the United States, and complete the metallurgy of silver and gold. It will be remembered that Dr. Percy's volume on Lead contained much relating to the metallurgy of silver.

5. *An historical sketch of Henry's contribution to the Electromagnetic Telegraph; with an account of the origin and development of Professor Morse's invention*, by WILLIAM B. TAYLOR. 103 pp. 8vo. Washington, 1879.—This pamphlet is reprinted from the Smithsonian Report for 1878. It contains a well-digested account of the successive steps in the development of the electric telegraph, from the middle of the eighteenth century, down. It has special reference, however, to the very important contributions of Professor Henry toward its practical establishment and final success.

6. Bulletins of the United States National Museum. The following are the contents of numbers recently issued:

NO. 12. Contributions to North American Ichthyology, No. 3; A: On the distribution of the Fishes of the Alleghany Region of South Carolina, Georgia, Tennessee, with description of new or little known species, by D. S. Jordan and A. W. Brayton; B: A synopsis of the Family Catostomidæ, by D. S. Jordan. 237 pp. Washington, 1878. NO. 13. The Flora of St. Croix and the Virgin Islands, by Baron H. F. A. Eggers. 133 pp., 1879. NO. 14. Catalogue of the Collection illustrating the animal resources and the fisheries of the United States, prepared under the direction of G. Brown Goode. 351 pp., 1879. NO. 15. Contributions to the Natural History of Arctic America made in connection with the Howgate Polar Expedition, 1877–78, by Ludwig Kumlien, Naturalist of the Expedition, 179 pp., 1879.

7. *Transactions of the Connecticut Academy of Arts and Sciences*, Vol. V, Part I, 257 pp. 8vo, with 24 plates. New Haven, 1880. The contents of the volume are as follows:—

Synopsis of the Pycnogonida of New England, by Edmund B. Wilson, with plates 1 to 7; The Stalk-eyed Crustaceans of the Atlantic Coast of North America north of Cape Cod, by S. I. Smith, with plates 8 to 12; A list of the Brazilian Echinoderms, with notes on their distribution, etc., by Richard Rathbun; The Comet of 1771: investigation of its orbit, by William Beebe; The Cephalopods of the Northeastern coast of America, by A. E. Verrill, with plates 13 to 25.

Reports on the Results of Dredging under the supervision of Alexander Agassiz in the Gulf of Mexico, 1877-78, by the U. S. Coast Survey Steamer "Blake," Lieut.-Commander C. D. Sigsbee, U. S. N. commanding. V.—General conclusions from a preliminary examination of the mollusca, by W. H. Dall. (Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass., vol. vi, No. 3).

APPENDIX.

Art. XLI. — *On the Efficiency of Edison's Electric Light;* by Professor H. A. Rowland of the Johns Hopkins University, and Professor George F. Barker of the Univ. Pennsylvania.

The great interest which is now being felt throughout the civilized world in the success of the various attempts to light houses by electricity, together with the contradictory statements made with respect to Mr. Edison's method, have induced us to attempt a brief examination of the efficiency of his light. We deemed this the more important because most of the information on the subject has not been given to the public in a trustworthy form. We have endeavored to make a brief but conclusive test of the efficiency of the light, that is, the amount of light which could be obtained from one horse power of work given out by the steam engine. For if the light be economical, the minor points, such as making the carbon strips last, can undoubtedly be put into practical shape.

Three methods of testing the efficiency presented themselves to us. The first was by means of measuring the horse power required to drive the machine, together with the number of lights which it would give. But the dynamometer was not in very good working order, and it was difficult to determine the number of lights and their photometric power, as they were scattered throughout a long distance, and so this method was abandoned. Another method was by measuring the resistance of, and amount of current passing through a single lamp. But the instruments available for this purpose were very rough, and so this method was abandoned for the third one. This method consisted in putting the lamp under water and observing the total amount of heat generated in the water per minute. For this purpose, a calorimeter, holding about 1¼ kil. of water, was made out of very thin copper: the lamp was held firmly in the center, so that a stirrer could work around it. The temperature was noted on a delicate Baudin thermometer graduated to $0^{\circ}{\cdot}1$ C.

As the experiment was only meant to give a rough idea of the efficiency within two or three per cent, no correction was made for radiation, but the error was avoided as much as possible by having the mean temperature of the calorimeter as near that of the air as possible, and the rise of temperature small. The error would then be much less than one per cent.

A small portion of the light escaped through the apertures in the cover, but the amount of energy must have been very minute.

In order to obtain the amount of light and eliminate all changes of the engine and machine, two lamps of nearly equal power were generally used, one being in the calorimeter while the other was being measured. They were then reversed and the mean of the results taken. The apparatus for measuring the light was one of the ordinary Bunsen instruments used for determining gas-lights, with a single candle at ten inches distance. The candles used were the ordinary standards burning 120 grains per hour. They were weighed before and after each experiment, but as the amount burned did not vary more than one p. c. from 120 grains per hour, no correction was made.

As the strips of carbonized paper were flat, very much more light was given out in a direction perpendicular to the surface than in the plane of the edge. Two observations were taken of the photometric power, one in a direction perpendicular to the paper, and the other in the direction of the edge, and we are required to obtain the average light from these. If L is the photometric power perpendicular to the paper, and l that of the edge, then the average λ will evidently be very nearly

$$\lambda = \mathrm{L}\int_{\frac{1}{2}\pi}^{0} \cos\alpha \sin\alpha \, d\alpha + l\int_{\frac{1}{2}\pi}^{0} \sin^2\alpha \, d\alpha$$

$$\lambda = \tfrac{1}{2}\mathrm{L} + \frac{\pi}{4} l$$

In the paper lamps we found $l = \frac{1}{8}\mathrm{L}$ nearly; hence $\lambda = \frac{3}{5}\mathrm{L}$ nearly.

The lamps used were as follows:

No.	Kind of carbon.	Size of carbon.	Approximate resistance when cold.
580	paper	large	147 ohms.
201	"	"	147 "
850	"	small	170· "
809	"	"	154 "
817	fiber	large	87 "

The capacity of the calorimeter was obtained by adding to the capacity of the water, the copper of the calorimeter and the glass of the lamp and thermometer. The calorimeter and cover weighed 0·103 kil. and the lamps about 0·035 kil.

First experiment, No. 201 in calorimeter and No. 580 in photometer; capacity of calorimeter $= 1{\cdot}153 + {\cdot}009 + {\cdot}007 = 1{\cdot}169$ kil. The temperature rose from 18°·28 C. to 23°·11 C. in five minutes, or 1°·75 F. in one minute. Taking the mechanical equivalent as 775·, which is about right for the degrees of this thermometer, this corresponds to an expenditure of 3486 foot pounds per minute. The photometric power of No. 580 was 17·5 candles maximum, or 13·1 mean, λ.

When the lamps were reversed, the result was 3540 foot pounds for No. 580, and a power of 13·5 or 10·1 candles mean.

The mean of these two gives, therefore, a power of 3513 foot pounds per minute for 11·6 candles, or 109·0 candles to the horse power.

To test the change of efficiency when the temperature varied, we tried another experiment with the same pair of lamps, and also used some others where the radiating area was smaller, and, consequently, the temperature had to be higher to give out an equal light.

We combine the results in the following table, having calculated the number of candles per indicated horse power by taking 70 per cent of the calculated value, thus allowing about 30 per cent for the friction of the engine, and the loss of energy in the magneto-electric machine, heating of wires, etc. As Mr. Edison's machine is undoubtedly one of the most efficient now made, it is believed that this estimate will be found practically correct. The experiment on No. 817 was made by observing the photometric power before and after the calorimeter experiment, as two equal lamps could not be found. As the fiber was round, it gave a nearly equal light in all directions as was found by experiment.

...mps used in		Photometric power		Capacity of Calorimeter in pounds.	Rise of temperature in degrees F.	Energy per minute in foot-pounds.	Mean number of candles per horse power of electricity.	Mean number gas jets of 16 candles each per horse power of electricity.	Mean number of gas jets per indicated horse power.
...lor-...eter	Photo-meter	measured perpen-dicular to paper, L.	Average, λ						
01	580	17·5	13·1	2·57	1°·75	3486·	109·0	6·8	4·8
80	201	13·5	10·1	2·82	1°·62	3540·			
80	201	38·5	28·9	2·74	2°·44	5181·	204·3	12·8	8·9
01	580	44·6	33·5	2·76	2°·29	4898·			
50	809	19·0	14·3	2·81	1°·14	2483·	133·4	8 3	5·8
09	850	12·2	9·2	2·79	1°·54	3330·			
817			17·2	2·73	1°·28	2708·	209·6	13·1	9·2

The increased efficiency, with rise of temperature, is clearly shown by the table, and there is no reason, provided the carbons can be made to stand, why the number of candles per horse power might not be greatly increased, seeing that the amount which can be obtained from the arc is from 1000 to 1500 candles per horse power. Provided the lamp can be made either cheap enough or durable enough, there is no reasonable doubt of the practical success of the light, but this point will evidently require much further experiment before the light can be pronounced practicable.

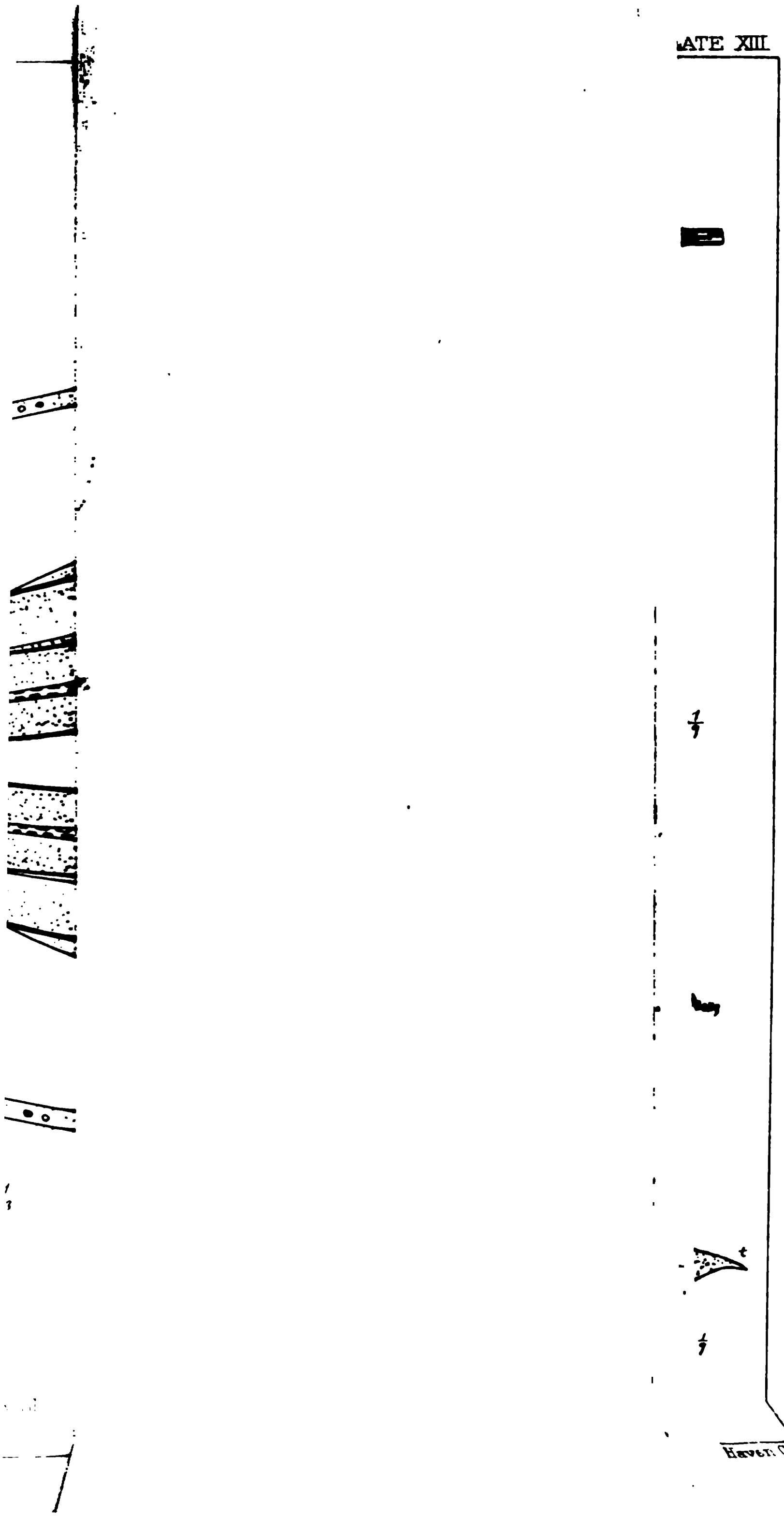
In conclusion, we must thank Mr. Edison for placing his entire establishment at our disposal in order that we might form a just and unbiased estimate of the economy of his light.

OBITUARY.

Professor WILLIAM T. RŒPPER of Bethlehem, Pennsylv died on the eleventh of March at the age of seventy. fessor Rœpper was born in the village of Peilau, nea Moravian settlement of Gnadenfrei, in Lower Silesia, Ger March 7th, 1810. In early life he qualified himself for servi the Moravian Church, and for several years taught at di church schools. He came to America in 1840, at the requ the authorities, to engage in the financial work of the Mor Church, and was employed in this until 1869, residing m the time at Bethlehem. At the opening of the Lehigh Univ in 1866, Mr. Rœpper was appointed Professor of Mineralog Geology, and curator of the museum. He retained the profe chair only three years, discharging his duties with marked s during that time, but he remained curator of the museum 1871. The latter years of his life were spent in the scientifi historical studies in which he was so much interested.

In the death of Professor Rœpper the science of his ad country has met with a real loss. Independent of his scie attainments, he was a man of unusual culture, a thorough sc in the classics and in history, and an accomplished musicia was to mineralogy, however, that he especially devoted hi and in this branch of science he occupied a high po The mathematical relations of the forms of crystals was a s to which he gave much study. He was not less diligent i chemical investigation of minerals, and his thorough know of the practical side of mineralogy caused his opinion as an ex to be frequently sought by those engaged in the mining smelting of ores. The discovery by him of deposits of zinc in the Saucon Valley, Penn., was one which did much to be the town in which he resided, but from which he gained no himself. He contributed several papers on mineralogical subj to this Journal; one of these deserves especial mention beca mineral species there described, an iron-manganese-zinc chrys from Stirling Hill, N. J., is now called *Rœpperite* after Those who knew him well will appreciate that, as the resu his patient work, his contributions to scientific literature m have been much more numerous but for the delicate modesty lack of desire for outside reputation which characterized him.

Professor Rœpper was a man of most genial and attrac personal character, who will be long remembered by all who the privilege of his intimate acquaintance.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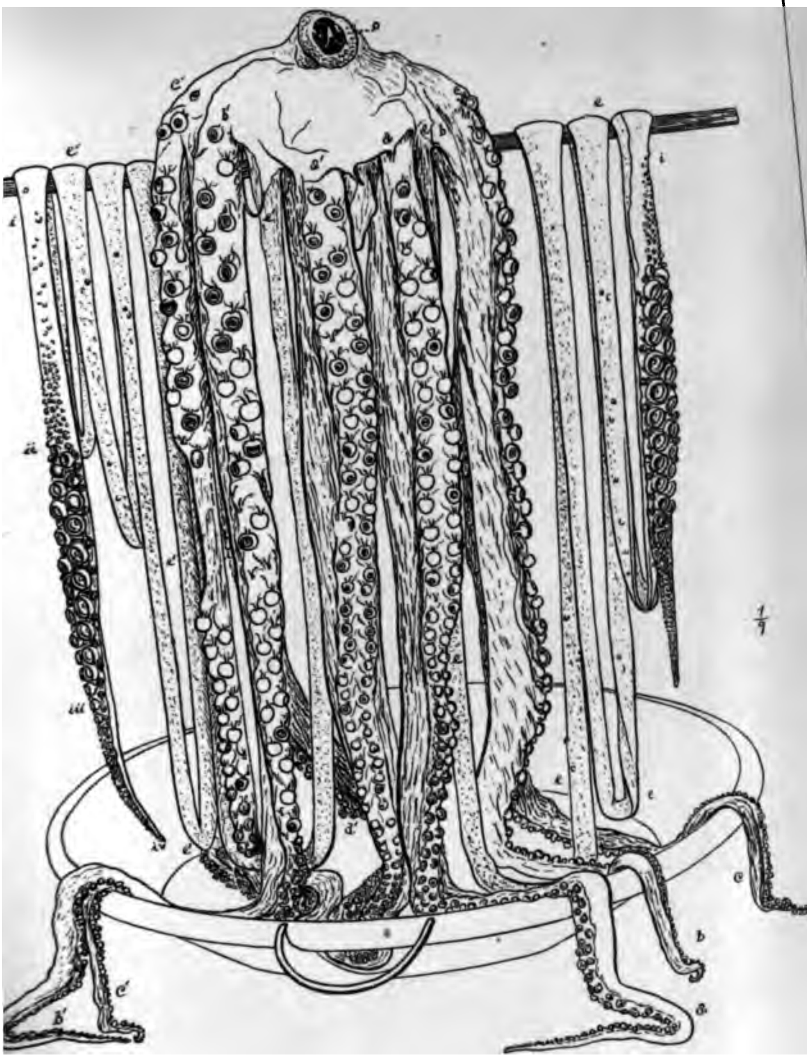

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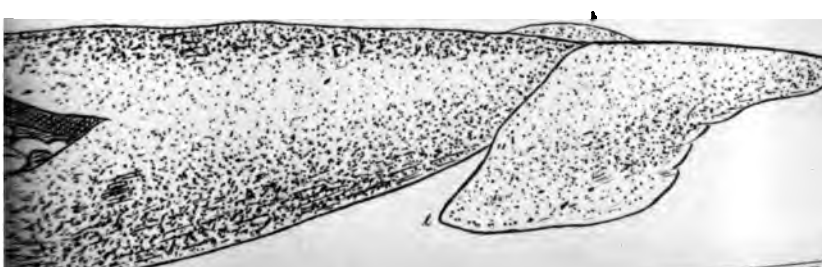

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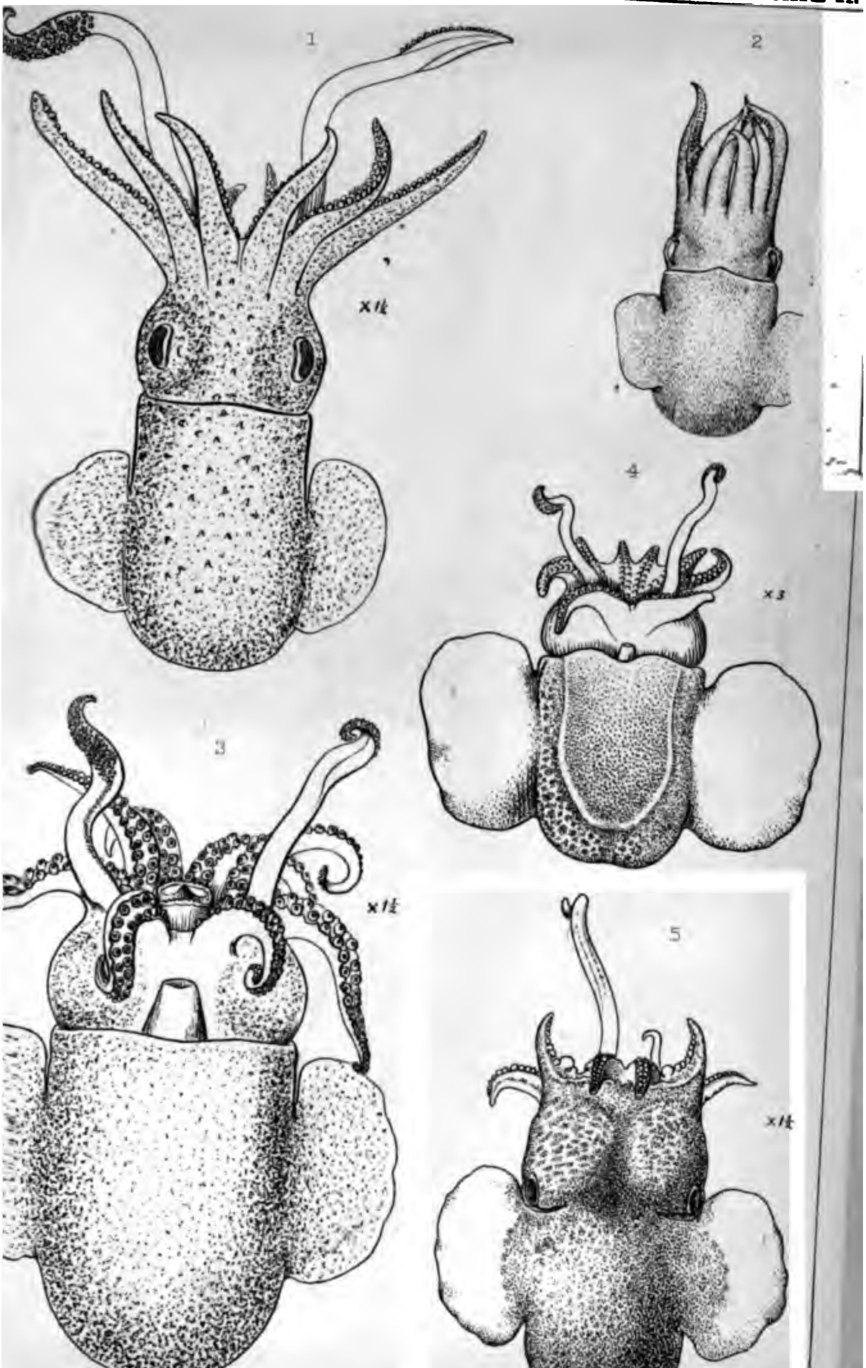

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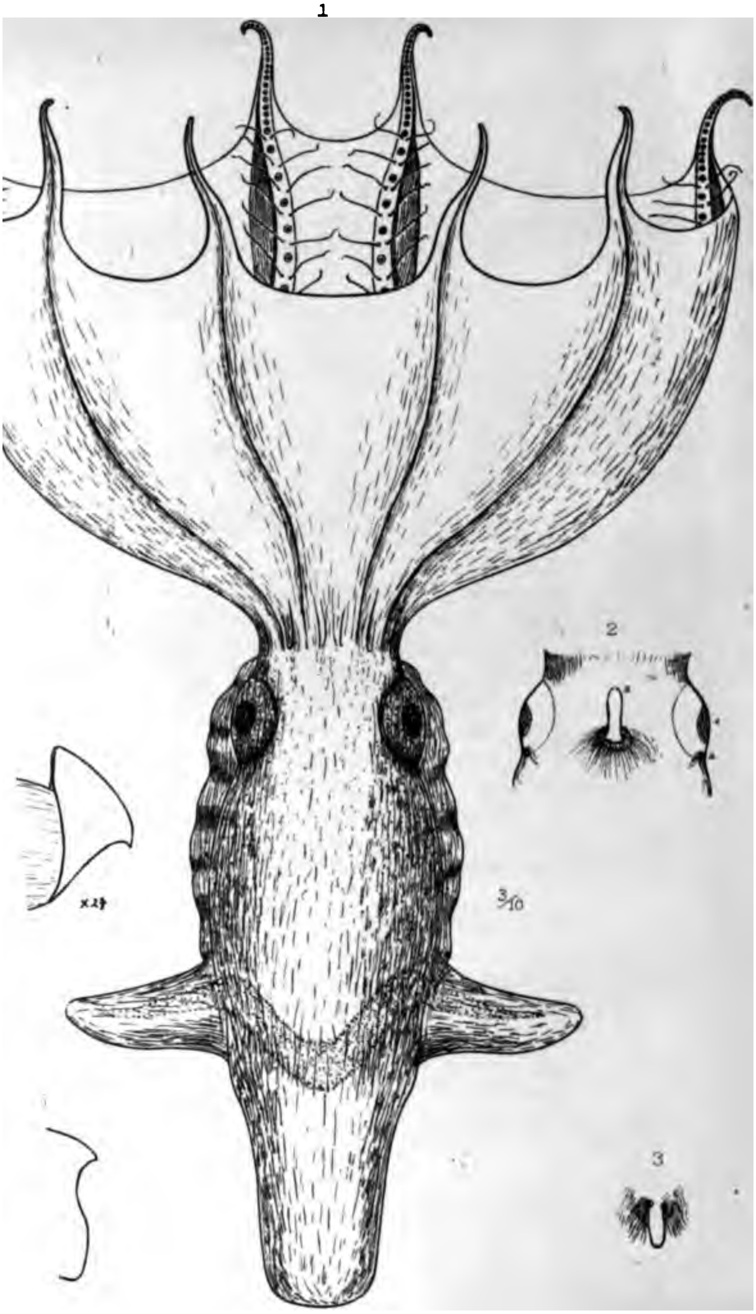

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AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XLII.—*The Outlet of Lake Bonneville*; by G. K. GILBERT.

SOME of the readers of the Journal will remember that the name "Lake Bonneville" has been applied to a great body of water which formerly covered the desert basins of Utah. Its most conspicuous vestiges are its shore lines, and from them it is known that the ancient water surface was more than ten times as great as that of Great Salt Lake, and the ancient water level was about one thousand feet above the modern.

It was early surmised that the ancient lake was freshened by overflow, but the point of discharge was for a long time undiscovered, and it may be said to be still in controversy. The present paper takes up the subject of the outlet where it was left nearly two years ago.

In this Journal for April, 1878, the writer maintained that the point of outflow was Red Rock Pass, Idaho, at the north end of Cache Valley; that the discharging stream descended through Marsh Valley and thence continuously to the Pacific Ocean; and that, flowing over soft material at first, it gradually excavated at the Pass a channel more than three hundred feet deep, and lowered the lake level by the same amount. In the June number of the Journal, Dr. A. C. Peale controverted my conclusion, declaring, first, that the original altitude of Red Rock Pass was considerably below the highest level of Lake Bonneville; second, that the ancient shore line exists in Marsh Valley at the north of the pass, just as in Cache Valley at the south; and finally, that the real point of discharge, when the water stood at the Bonneville level, was about forty-five miles north of Red Rock Pass.

Dr. Peale treats, in the same article, a question of priority and other matters of purely personal interest, and his remarks thereon invite reply, but I have a strong distaste for personal controversy, and I am confident that the readers of the Journal—not even excepting Dr. Peale—will cheerfully excuse me if I refrain. I shall therefore confine myself to the question of outlet.

Within a few months I have revisited Marsh Valley and Red Rock Pass, and have examined the lower cañon of the Portneuf. My observations do not serve to diminish materially the disparity between Dr. Peale's conclusions and my own, but they throw light on some of our contradictions in matters of simple observation. These contradictions depend in part upon a misinterpretation of certain terraces, and will be better understood after a brief enumeration of the characters by which terraces of diverse origin may be distinguished.

The term *terrace* is applied in topography to a level surface, or one of very gentle slope, limited on one side by a surface which *descends* at a greater angle, and usually limited on the other by a surface which *ascends* at a greater angle. Where the limiting slope is steep it is called a *scarp*. A scarp may stand above a terrace, rising from its inner edge and facing toward it, or it may lie below it, falling from its outer edge and facing from it. Most terraces are margined by scarps on one edge or the other, and some on both.

Terraces are produced in at least five different ways, namely: by differential erosion, by streams, by waves, by differential deposition, and by displacement.

Terraces by Differential Erosion arise wherever a series of dissimilar strata lying nearly horizontal are subjected to rapid erosion. The soft strata are destroyed more rapidly than the hard, and the latter, where they overlie soft beds, are undermined so as to break off by vertical fracture. A stair-like system of terraces and scarps is thus formed, in which each terrace marks the outcrop of a soft rock and each scarp the outcrop of a hard one.

These terraces are distinguished from all others by the constant relation of form to stratigraphic structure.

A *Stream terrace* is produced whenever a stream, which has for a long time, flowed at one level, is induced by changed conditions to excavate a new channel at a lower level. While flowing at the upper level the water forms a broad flood plain. By the subsequent excavation this plain is in part destroyed, and what remains becomes a terrace. A scarp of even height separates the terrace from the new channel of the stream or from a new flood plain.

It is characteristic of stream terraces that they slope in the direction of the stream that carved them.

Wave terraces are found on the shores of all bodies of water. The action of waves, combined with that of currents, carves away the land on all salients. The direct action is confined to a few feet above and below the water-level, but whatever is undermined by the waves is thrown down by gravity and brought within their reach. The results of the erosion are, first, a broad terrace lying under shallow water and sloping gently from the shore; and, second, a sea-cliff or scarp springing from the water's edge.

It is one of the chief characteristics of a wave terrace that its upper edge, where it joins the scarp, follows a water line. In the case of Lake Bonneville the water has long since disappeared from the terraces, but the horizontality remains as a conspicuous feature—subject only to slight modification by orographic displacement.

Delta terraces are produced by differential deposition. Where a stream enters a lake or other body of deep water, the chief part of the detritus it transports is deposited at its mouth. The effect of this is to extend its bed on the side toward the deep water. As the mouth protrudes a deposition takes place along the bed, so as to maintain a constant declivity of channel, and soon the bed is so raised that the water finds a lower way at one side and leaves it. By a repetition of this process the mouth of the stream is shifted from point to point, and the delta is made to encroach on the lake along its whole face. The form eventually produced is that of a terrace sloping gently down to the shore and there limited by a submerged scarp. The declivity of the scarp depends on the coarseness of the material deposited. The declivity of the terrace is identical with that of the stream which formed it. The contour separating the terrace from the scarp is a curve convex toward the lake.

A chief characteristic of a delta terrace is that its lower edge, where it joins the scarp, follows a water line and is horizontal. In the delta terraces of Lake Bonneville the horizontality remains though the water has disappeared.

Terraces by displacement are usually produced by faulting. A fault traversing a surface of gentle slope drops down the portion at one side or lifts the portion at the other, and separates the two by a scarp. The scarp is the only feature added to the topography, but by its addition the raised portion of the slope becomes a terrace.

Whatever is characteristic of the terrace by displacement pertains to the scarp. A *fault scarp* usually holds an even height for long distances. It maintains an even, often a

straight, course across the country, ascending and descending slopes without change of direction. It is only by accident that it is ever horizontal.

Wave terraces and delta terraces are associated phenomena of shore lines. They agree in the essential character of horizontality, and by that are distinguished from all other terraces. They have no such relation to rock structure as have terraces by differential erosion. Their scarps are not of even height like those of stream terraces. Their course across the country has the sinuosity of a contour, and not the directness of a line of orographic displacement.

Returning now to the consideration of the outlet of Lake Bonneville, let us glance a moment at the general features of the vicinity. Cache Valley and Marsh Valley are parts of the same trough-like depression, separating two mountain ranges. The general trend of the trough and of the ranges is a little west of north. Marsh Valley lies to the north of Cache Valley. It is thirty-five miles long and has a maximum width of fourteen miles. Cache Valley is fifty-five miles in length and eighteen in width. At the north end of Marsh Valley the trough is ended by the junction or close approximation of the bordering ranges. At the south end of Cache Valley it is interrupted by a low cross range. At Red Rock Pass, where the two valleys adjoin, the trough is restricted by spurs from the two ranges, and a few protruding crags show that there is a low cross ridge of limestone buried by more recent deposits. On the west side of Cache Valley there is a low interval in the bounding range—so low that the Bonneville flood overtopped it and made Cache Valley a bay of the great lake. At this point Bear River has cut a narrow gorge, through which the drainage of the entire valley finds its way to the basin of Great Salt Lake. Bear River and several other streams enter Cache Valley from the east by cañons traversing the bounding range. In like manner the Portneuf cuts through the eastern range to enter Marsh Valley, and then passes from it at its extreme northwestern angle by a deep cut valley of erosion, opening to the great plain of the Snake River.

According to Dr. Peale, the Bonneville flood filled Cache and Marsh Valleys to the same level. Red Rock Pass was only a point of stricture of the lake, and the outlet was at the north. He mentions terraces in Marsh Valley and gives their altitudes, impliedly regarding them as shore terraces. According to my own observations, Cache Valley was occupied by Lake Bonneville, and Marsh Valley was not so occupied, but was traversed from south to north by the stream which overflowed at the north end of Cache Valley. There are no shore terraces nor

other lake phenomena of the Bonneville epoch in Marsh Valley.

In revisiting Marsh Valley I traversed it from end to end and made careful search for ancient shore terraces. The most favorable position from which to detect such vestiges is one which brings the eye in the same horizontal plane with them. The apparent distortion which arises from perspective is thus avoided, and all the little modifications of surface wrought by the waves, being brought into one straight line across the landscape, appeal to the eye by their *ensemble*. The most favorable light for the observation is one which throws the scarps into shadow or deep shade, and thus contrasts them with the adjoining terrace faces. In examining Marsh Valley I gave particular attention to the selection of stations and of light, and I considered my inspection of no part of the margin complete until I had viewed it from the proper height and in a favorable light. I ascended to a level corresponding to that of the Bonneville beach at ten different points, and the series of views thus obtained omitted no portion of the valley. I saw stream terraces and displacement terraces of considerable magnitude and a few inconspicuous terraces due to unequal erosion, but no wave terrace and no delta terrace.

If Marsh Valley had really been filled by the lake, as Cache Valley was, there could be no difficulty in finding evidence of the fact. The water would have been eight or ten miles broad and 400 feet deep, and the waves raised by the wind on a bay of such dimensions would leave most conspicuous monuments of their force. Arms of Lake Bonneville two or three miles in width and less than 100 feet in depth have elsewhere been traced out by means of their distinct and well-characterized shore lines, and this under conditions of slope, etc., similar to those existing in Marsh Valley.

But if Marsh Valley contained no lake, of what nature are the terraces adduced by Dr. Peale in support of his conclusions? The question is easier proposed than answered, but I think a partial explanation can be given.

The first locality he mentions is "two miles north of Red Rock Pass, on the east side of the valley." At this place there is a conspicuous stream terrace at about the right altitude to personate a delta terrace of the Bonneville series. Its surface is part of an alluvial cone formed by Marsh Creek before the Bonneville epoch, and its scarp is one wall of the channel worn by the outflowing river during that epoch. The river pared away the margin of the sloping plain spread by the creek and left the remainder as a terrace. The edge of this terrace is, at its highest point, 50 feet higher than the nearest trace of the Bonneville beach, two miles away; and it descends northward

until it passes below the level. On top of the terrace and about half a mile back (east) from its edge, there is a second scarp from 10 to 20 feet in height, and due to displacement. This fades out to the northward and at the same time descends with the general slope. Dr. Peale's observation probably refers to one or the other of these scarps, and in either case fails to take account of the lack of horizontality.

His second locality is "six miles west of Red Rock Pass." The only terraces I found at that point are stream terraces, sloping so conspicuously to the N.E. and N.W. that it is hard to believe they were mistaken for beaches. A few miles beyond there is a fault scarp with a much stronger semblance, and where this crosses the old freight road which ascends to Malade Pass it has very nearly the altitude appropriate for the Bonneville Beach. Its true character, however, cannot be mistaken when it is critically examined.

His third locality, "twenty-six miles from Red Rock Pass on the west side of the valley," was not identified.

Passing now from the subject of the general position of the outlet to the question of its precise location at the time of the commencement of the outflow, I find myself able to make a concession to Dr. Peale. I at first supposed that the divide originally lay between Red Rock and Hunt's Butte, just as it lies to-day, and I so described it. A careful reëxamination of the locality has convinced me that I was in error, and has led me to assign it a position two miles north of Red Rock. Dr. Peale placed it about forty-five miles north of Red Rock, so that my new determination is nearer to his than my old was.

With the aid of the accompanying map I hope to make the chief topographic features of the locality, and the history of the outflow, clear to the reader.

At the point of greatest orographic constriction, that is, where the mountains bordering the general trough, approach nearest to each other, there is evidence of a connecting ridge of limestone. This ridge is so low that only a few peaks of its serrated crest project through the superficial deposits. To it belong Red Rock (R), Hunt's Butte (H) and the hills marked L, L, L. Just north of the ridge Marsh Creek issues from the mountains at the east. It flows southwestward for three miles, makes a sharp turn about Hunt's Butte, and then flows northward to Marsh Valley, occupying the old river bed all the way from Hunt's Butte. It is the largest stream of the vicinity of the pass, and has thrown so much debris into the river bed that it has determined the modern divide at the point of its accession. It is contained by high banks all the way from its mountain cañon to Hunt's Butte and has no freedom to shift its course over its own alluvion until it enters the river bed. Before the Bonneville epoch,—before the river bed was cut, the creek had dug no deep channel outside the mountain cañon and was free to roam at will. It distributed its debris equally in all directions, building a fan-shaped alluvial plain (A) with its apex at the mouth of the cañon. All parts of this plain radiated with equal slope from its apex, and its surface was part of a low-crowned cone. In brief it was an *alluvial cone.* It extended westward until it met the foot-slopes of a spur of the western range and that point of meeting (x), which was about two miles north of Red Rock, was the divide between Cache and Marsh Valleys. When the brimming waters of Lake Bonneville were discharged across it, a river channel was slowly excavated, and the margin of the alluvial cone was cut away. The edge of the surviving slope is fifty feet higher than the Bonneville beach at Hunt's Butte and therefore fifty feet higher than the original divide. As the channel of outflow deepened by wear, the lake level was lowered and its shore retreated southward. The head of the outflowing stream fol-

lowed the retreating shore until, at the Provo stage of Lake Bonneville—the lowest stage of outflow,—the point of outlet was at the edge of what is called Round Valley Marsh (*y*), nine miles south of Red Rock. When the lake dried away, the divide was left at that place, but Marsh Creek has resumed control of it by constructing an alluvial cone in the old river bed at Hunt's Butte (*a*) and building it higher than the level of the last discharge.

The Bonneville water line, so far as it survives, is represented by the heavy lines B, B. Its restored continuation and the restored banks of the outflowing river are represented by heavy broken lines. The margins of the water at its lowest, or Provo stage, when the point of outlet was at *y*, is shown by lighter broken lines.

While Marsh Creek was building its ancient alluvial cone, it ran in turn over all parts of it. At times it passed south of the divide and flowed to the Great Basin. At other times it passed north of the divide and flowed to the Portneuf river. When the outflow of the lake was initiated and the water level began to be lowered by the deepening of the channel of outflow it chanced that the creek was running over the southern part of its cone, and discharging into the lake at Hunt's Butte. The lowering of its point of discharge caused the creek to cut away its bed instead of building it up and it ceased to shift its channel. As the river bed grew deeper, so did the channel of the creek, and the latter now flows several hundred feet below the top of its old cone. When, by the building of its new cone in the abandoned river bed, the creek recovered possession of the divide, it resumed its ancient practice of discharging alternately to the north and to the south. To-day it is a tributary of the Portneuf. The next freshet may clog its channel with debris and divert it to the drainage of Bear river.

After the publication of my former article, I learned that the outlet had been independently discovered by my friend, Mr. Gilbert Thompson, and I am glad of this opportunity to give him credit. Mr. Thompson is not a professed geologist, but he is an expert topographer, and his close study of the natural forms, which it is his work to delineate, has more than once led to observations valuable to the geologists with whom he has been associated. I quote the following from his letter dated April 10, 1878:

"Thanks for your brochure, 'the Ancient Outlet of Great Salt Lake.' The past season I was along the northern limits of the ancient lake, between 111° and 112° 22′ 30″ and was absolutely ignorant of your examination in 1876 and its results. . . . I was very much interested in the general subject of its limits and also of its outlet. . . . Toward

the last of the season, as I surveyed from the north the road through Red Rock Pass, after noting the remarkable topographical features of Marsh Creek, and keeping a close run of the profile as given by the aneroid, I was delighted at Red Rock to see unmistakable evidences of the ancient outlet of Great Salt Lake. . . . . Thus you may have the gratification of knowing of an independent and entirely unbiased verification of your determination of this point; and it is nowhere else in the limits I have mentioned."

ART. XLIII.—*The Chemical and Geological Relations of the Atmosphere;** by T. STERRY HUNT, LL.D., F.R.S.

QUESTIONS concerning the condition of the terrestrial atmosphere in former periods of the earth's history, and its geological relations, have occupied the attention of naturalists, physicists and chemists. Brongniart long since suggested that the abundant vegetation of the Coal-period indicated the existence of a large proportion of carbonic acid in the air at that time. Ebelmen, however, appears to have been the first to clearly understand the great geological significance of the atmosphere, and in his two remarkable memoirs on the decomposition of rocks, published in the Annales des Mines in 1845 and 1847,† treated the subject in its atmospheric relations with much research and philosophic breadth. Starting from the chemical changes of crystalline silicate rocks, he considered both the conversion of feldspars into kaolin, and the decay of protoxide-silicates, such as amphibole and olivine. The sub-aerial decomposition of the feldspars had already been shown by Berthier to result in the separation, in a soluble form, of the protoxide-bases, together with a portion of silica, from an insoluble aluminous silicate of definite composition. The analyses of Ebelmen now established the fact that the protoxide-silicates just mentioned, lose, under similar conditions, the whole of their lime and magnesia, and nearly the whole of their silica, leaving little behind save the higher oxides resulting from the fixation of atmospheric oxygen by the ferrous and manganous oxides of the silicates;

* A summary of the views presented in this memoir was given at Dublin, in August, 1878, before the British Association for the Advancement of Science. An abstract thereof appeared in the Proceedings, and will be found in *Nature* for August 29, 1878 (vol. xviii, p. 475.) The principal conclusions of the memoir are also embodied in a communication made by the author to the French Academy of Sciences, and published in the Comptes Rendus of September 23, 1878 (vol. lxxxvii, page 452.) They will also be found set forth in the preface to a second edition of the writer's Chemical and Geological Essays (pages ix–xix) published in the spring of the same year.

† 4th Series, vols. vii and xiii. These memoirs will also be found in the Receuil des Trav. Scient. de M. Ebelmen; Paris, 1855, vol. ii, pp. 1–79.

the soluble bases being in all cases removed by atmospheric waters in the form of carbonates. Such a decomposition of these silicates shows that the removal of silica in soluble form does not depend on the intervention of alkalies.

The atmosphere of our earth at a pressure of 760 millimeters has a weight of 10,333 kilograms to the square meter, of which the oxygen equals 2,376, and the carbonic dioxide (if we take Boussingault and Léwy's determination of four and a half parts in 10,000 parts by weight) 4·64* kilograms. The alkali of 100 parts of orthoclase would require for its neutralization 7·8 parts of carbonic dioxide, so that a cubic meter of this silicate, of specific gravity, 2·5, would, by the calculation of Ebelmen, fix, in the process of decay, 195 kilograms of the gas. From this it results that a layer of orthoclase over the earth of 0·0238 meter, or one of less than 1·0 meter over one-fortieth of its surface, would, in its decomposition, absorb the whole amount of this gas now present in the atmosphere. Ebelmen further calculated that the formation of a layer of kaolin by this process, 500 meters in thickness, would require an amount of carbonic dioxide equal to many times the weight of the present atmosphere.

We have repeated and extended these calculations, with revised equivalent weights, and with the following results: A cubic meter of orthoclase, with a density of 2·5, and containing theoretically 16·9 per cent. of potash, equivalent to 7·89 of carbonic dioxide, would absorb in kaolinization 197·3 kilograms of this gas, while a cubic meter of albite of density 2·6, containing 11·8 of soda, equivalent to 8·37 of carbonic dioxide, would require not less than 217·6 kilograms of the same. The figure of 195 kilograms, adopted by Ebelmen, was thus below the truth, and we may, in view of the considerable proportion of soda-feldspar in the oldest crystalline rocks, conveniently assume 200 kilograms as the amount of carbonic dioxide required to unite with the alkali from a cubic metre of orthoclase or albite, and form therewith a neutral carbonate.

In such a decomposition, 100 parts of orthoclase give theoretically about 46·5 parts of kaolin, so that 1·0 meter in thickness of orthoclase of the above density should yield 0·447 meter of kaolin of density 2·6. If we assume this process to have consumed for a cubic meter or 2500 kilograms of orthoclase, 200 of carbonic dioxide, we find that a layer of 51·66 meters of orthoclase, or its equivalent of quartzo-feldspathic rock, in undergoing the same change, would absorb 10,333 kilograms of this gas, equal to the entire weight of the present atmospheric column, and would yield a layer of pure kaolin 23·7 meters in thickness. The production of a stratum of

* This, by an error in Ebelmen's memoir, is given as only 1·24 kilograms.

ıolin 500 meters in thickness over the whole surface of the obe, would thus require an amount of carbonic dioxide ual to more than twenty-one times the entire weight of our esent atmosphere.

The absorption of this gas in the decay of silicates like rnblende, pyroxene and olivine is far greater. If we assume r convenience a hornblende containing 20·0 per cent of magsia, and 14·0 of lime, with a density of 3·0 (which figures e not above the average) we find that it will require 33·0 r cent, or in round numbers one-third its weight of carbonic oxide to convert these two bases into neutral carbonates; so at a meter-cube of hornblende, weighing 3000 kilograms, ould consume not less than 1000 kilograms of carbonic oxide. In other terms, the decay of 10⅓ meters of such rnblende (or its equivalent in hornblendic rock) would sorb 10,333 kilograms, or a whole atmosphere of this gas, ing five times as much as is taken up in the kaolinization of e same volume of orthoclase.

The hornblendes in question are seldom without several undredths of iron as ferrous oxide, which is peroxidized in e process of decay, and, with a little silica, is the chief soluble residue in the case of non-aluminous hornblendes. this connection we revert to a farther calculation by Ebelen, who pointed out that the conversion of 21,357 kilograms ferrous oxide into 23,750 kilograms of ferric oxide would nsume the whole of the 2,373 kilograms of oxygen conined in the present atmosphere; so that if we suppose the istence over the whole earth of 1,000 meters of sediments erived from the decay of crystalline rocks, and containing ly one per cent of ferric oxide thus formed, this amount ould equal 25,000 kilograms per square meter of surface, quiring for its production from ferrous oxide the absorption a quantity of oxygen more than equal to that now contained our atmosphere.

Ebelmen, at the same time, referred to the well-known eoxidation of carbonic dioxide by growing vegetation, and so to the reduction, by decaying organic matters, of sulphates sulphids, with reproduction of carbonic dioxide, through hich the generation of metallic sulphids in nature gives to e atmosphere, in union with carbon, a portion of the oxygen reviously combined with sulphur and with the metals.

The following calculations may serve to bring still more lly before us the great geological significance of these atmosberic changes. The weight of a layer of pure carbon, with a ensity of 1·25 and a thickness of 0·7 meter, would require for s conversion into carbonic dioxide the whole of the oxygen f our present atmosphere. The separation of such an amount

of carbon by the process of vegetable growth must therefore have liberated the same volume of oxygen Again, a stratum of carbonate of lime of specific gravity 2·7, covering the earth with a thickness of 8·69 metres, (or one of dolomite of sp. gr. 2·85, and 7·58 meters thick) would contain an amount of carbonic dioxide equal in weight to the present atmosphere.*

It was in view of these processes that Ebelmen declared, in 1845, that "the decomposition and the reproduction of certain mineral species very abundant on the surface of the globe corresponds to important modifications in the composition of the atmosphere." He farther said, "Many circumstances tend to prove that in ancient geological periods the atmosphere was denser, and more rich in carbonic acid, and perhaps in oxygen, than at present. To a greater weight of the atmospheric envelop would correspond a stronger condensation of the solar heat, and atmospheric phenomena of a much greater intensity."† Similar conclusions with regard to the physical relations of a denser primeval atmosphere were subsequently announced by the late Edwin B. Hunt, in an essay on Terrestrial Thermotics, presented to the American Association for the Advancement of Science, in 1849, and published in its Proceedings for that year, page 135.

We may get a clearer notion of the problem before us by inquiring into the probable amounts of carbonic dioxide which have, in past ages, been abstracted from the atmosphere. In a communication to the British Association for the Advancement of Science, in 1877,‡ Mr. J. L. Mott concludes, as the result of calculations, that the average amount of unoxidized carbon to a square mile of the earth's crust cannot be less, and is probably many times greater than 3,000,000 tons; while a layer of 0·7 meters of carbon of density 1·25, (about that of coal) which we have calculated to be equal to the total atmospheric oxygen, would weigh only about 2,200,000 tons to the square mile. Mr. Mott rightly argues that the presence in the atmosphere of so great an amount of carbon in the form of dioxide would imply a condition of things incompatible with the existence of animal life, and at the same time concludes that its deoxidation would yield an excessive amount of oxygen. He is hence led to assume the existence in the earth of a constant amount of carbon, which is subject to an annual subterranean oxidation equal to the amount of carbon annually removed by vegetation; the source of the original amount of carbon being, in his hypothesis, left unexplained.

* T. Sterry Hunt on the Primeval Atmosphere, Proc. Amer. Assoc. Adv. Science, 1866, and Can. Naturalist, II, iii, 118.

† Ann. des Mines, IV, vii, 65; also Receuil des Trav. Scient. de M. Ebelmen, vol. ii, p. 55.

‡ Nature, vol. xvi, p. 406.

While some have imagined an inorganic origin to the carbon found in the form of graphite, and even to petroleum and to coal, sound reasoning is, we think, on the side of those who, starting from the conception of an originally oxidized globe, see no evidence of any process of deoxidation therein which does not, directly or indirectly, depend upon vegetable life, and hence assign an organic origin to all carbons and hydro-carbons. When we take into account the vast amounts of these, from the graphite of Eozoic times to the coals, lignites and petroleums of the Tertiary, we can scarcely doubt that the total amount of carbon which has been reduced from carbonic dioxide is equal to many times the equivalent of the oxygen now present in the atmosphere. Whether the great excess of oxygen thus liberated may perhaps have been absorbed in the production of ferric oxide, as above indicated, is a part of the problem before us.

It may here be noted that in addition to the fossil carbonaceous bodies already mentioned, the rocky strata of the earth include great thicknesses of pyroschists, which are argillaceous sediments more or less impregnated with hydro-carbonaceous matters allied to coal in composition. To give a single example; Newberry estimates the proportion of such matters diffused through the 300 or 400 feet of Devonian black shales which underlie the eastern half of Ohio, to equal fifteen per cent, and to be equivalent to a layer of coal fifty feet in thickness over the whole area.*

In this connection it must be considered that the chemical composition of the various hydrocarbonaceous fossil substances implies a deoxidation not only of carbonic dioxide but of water. The amount of liberated oxygen from the latter would equal, for the different coals and asphalts, from one-eighth to one-fourth, and for the petroleums, one-half of that set free in the deoxidation of the carbon which these hydrocarbonaceous bodies contain.

The amount of carbon removed from the atmosphere in a deoxidized form by vegetation is, however, small when compared with that which has been absorbed during the decomposition of silicates, and is now fixed as insoluble carbonates, chiefly in the form of limestones and dolomites. That both the alkaline carbonates liberated in the decay of feldspars, and the magnesian carbonate set free in like manner from magnesian silicates, must decompose the chlorid of calcium contained in the primitive ocean, thereby giving rise to alkaline and magnesian chlorides on the one hand, and to carbonate of lime on the other, is a consequence which seems to have escaped Ebelmen, and was pointed out by the present

* Geology of Ohio, vol. i, page 162.

writer in 1858. In 1862, however, there was opened a sealed packet which had been in 1844 deposited by Cordier with the French Academy of Sciences, and was found to contain views as to the origin of limestones and of sea-salt similar to those just stated.* Thus, in the present state of our knowledge we conclude that all carbonates of lime, whether directly formed by the decay of calcareous silicates, or indirectly through the intervention of carbonates of magnesia or alkalies, derive their carbonic dioxide from the atmosphere. The same must be said for the dolomites, magnesites and siderites.

We have already shown that a weight of carbonic dioxide equal to more than twenty-one times that of our present atmosphere would be absorbed in the production from orthoclase of a layer of kaolin extending over the earth's surface with a thickness of 500 meters, an amount which evidently represents but a small proportion of the results of feldspathic decay in the sedimentary strata of the globe. The aluminous silicates in the oldest crystalline rocks occur in the forms of feldspars and related species, and are, so to speak, saturated with alkalies or with lime. It is only in more recent formations, that we find aluminous silicates either free or with reduced amounts of alkali, as in the argillites and clays, in micaceous minerals like muscovite, margarodite, damourite and pyrophyllite, and in kyanite, fibrolite and andalusite, all of which we regard as derived indirectly from the more ancient feldspars.†

It has been shown that the disengagement of the carbonic dioxide from a layer of limestone covering the earth's surface with a thickness of 8·69 meters, would double the weight of the atmosphere. The existence of vast formations of limestone and dolomite, often many hundred meters in thickness, throughout all geological periods, will, it is believed, justify the conclusion that the carbonates of the earth's crust are equal to a continuous layer of limestone 869 meters thick, and probably to more than double this amount. From this it would follow that the earth contains, fixed in the form of carbonates, a quantity of carbonic dioxide, which, if liberated in a gaseous form, would be equal in weight to one hundred if not to two hundred atmospheres like the present. A considerable portion

* Hunt, Chem. and Geol. Essays, pp. 2 and 20.

† These considerations, and their stratigraphical bearings, first set forth in 1863 (Chem. and Geol. Essays, pp. 27 and 28), will be found further developed in the writer's report on Azoic Rocks, 2d Geol. Survey of Penn., 1878, p. 210. It is a question how far the origin of the various crystalline aluminous silicates named above is to be sought in a process of diagenesis in ordinary aqueous sediments holding the ruins of more or less completely decayed feldspars. Other aluminous rock-forming silicates, such as chlorites and magnesian micas, are however connected, through aluminiferous amphiboles, with the non-aluminous magnesian silicates, and to all these various magnesian minerals, as maintained in a previous paper in this volume (History of some pre-Cambrian Rocks, etc., page 270), a very different origin must be assigned.

of this was doubtless absorbed at an early period in the history of our globe, since the limestones of the Eozoic are of great thickness, and those of more recent times have been in part formed by the solution and re-deposition of portions of these older limestones.

The question now arises, whence came this enormous volume of carbonic dioxide which, since the dawn of life on our planet, has been fixed in the form of carbon and carbonates? The presence of even a small proportion of it at any one time in the terrestrial atmosphere is evidently incompatible with the existence of vegetable and animal life, and it may be added that the pressure of a column of this gas less than the minimum of 100 atmospheres which we have supposed, would suffice, at ordinary temperatures, for its partial liquefaction; the tension of liquid carbonic dioxide at 30°·7 C. being, according to Mareska and Donny, but eighty atmospheres. We are therefore forced to the conclusion that this gas was gradually supplied from a source either within the earth or beyond our atmosphere.

The difficulties of this problem were not overlooked by Ebelmen, though he apparently failed to recognize their full weight. He takes care to remark: "I do not pretend that this immense proportion of carbonic acid ever made part, at any one time, of the terrestrial atmosphere. . . . I see in volcanic phenomena the principal agent which restores to the atmosphere the carbonic acid which the decomposition of rocks removes from it." He then inquires whether the carbonic acid (carbonic dioxide) evolved from the earth's interior, comes from the decomposition of carbonates at great depths and high temperatures by reactions with silicious matters, or whether we may imagine, with Elie de Beaumont, the existence of an immense reservoir of carbonic acid dissolved in the supposed liquid interior of the earth as oxygen is held in fused litharge or in molten silver. In either case, remarks Ebelmen, the cessation of volcanic phenomena would be followed by the removal from the atmosphere of the last traces of carbonic acid, a process which would entail the extinction of all vegetable and animal life.

Of these two suggested sources of the terrestrial carbonic dioxide, a little reflection will show that although the first is doubtless a true one, and will serve to account for that which is so often disengaged from the earth, both in volcanic and non-volcanic regions (having a similar origin to the chlorhydric, sulphuric and boric acids evolved under analogous conditions—namely, the decomposition of saline compounds of aqueous origin),* it by no means meets the requirements of the problem.

* Hunt, Chem. and Geol. Essays, pp. 8 and 111.

As preceding calculations have shown,* it is not a question of a small amount of carbonic dioxide alternately removed from our atmosphere by sub-aerial reactions and restored to it by subterranean processes, but of a vast quantity of this gas which, at one time or another, has existed in the terrestrial atmosphere, but is now removed from the aerial circulation and locked up in the form of carbonates.

As regards the second source of carbonic dioxide, suggested by Ebelmen after Elie de Beaumont, it is, unlike the last, purely hypothetical. That the globe has a molten interior is, in the present state of our knowledge of terrestrial physics, very improbable, and if such exists, the notion that it intervenes directly in volcanic phenomena is still more so. The suggestion that such a molten interior might hold dissolved a great volume of carbonic dioxide appears, moreover, to be inconsistent with what we know of the behavior of furnace-slags, which, though formed in atmospheres highly charged with this gas, do not, as shown by their behavior in cooling, hold it in solution. The tendencies of modern geological thought and investigation, it may be said, lead to the conclusion that the seat of volcanic phenomena is to be found in sedimentary strata,* and that although the earth's interior intervenes as a source of heat, the carbonic dioxide disengaged from its crust is derived, as in the first hypothesis mentioned by Ebelmen, from the decomposition of carbonates previously generated by sub-aerial reactions.

The problem still before us is then to find the source of the vast amount of carbonic dioxide continuously supplied to the atmosphere throughout the geologic ages, and as continuously removed therefrom, and fixed in the form of carbonaceous matters and limestones. We have shown reasons for rejecting the theory which would derive this supply either from the earth's interior or from its own primal atmosphere, and must therefore look for it to an extra-terrestrial source. The new hypothesis, which we here advance, starts with the assumption that our atmosphere is not primarily terrestrial but cosmical, and that the air, together with the water surrounding our earth, (whether in a liquid or a vaporous state) belongs to a continuous elastic medium which, extending throughout the interstellary spaces, is condensed around attracting bodies in amounts proportional to their mass and temperature. This universal atmosphere (if the expression may be permitted,) would then exist in its most attenuated form in the regions fartherest distant from these centers of attraction; while any change in the gaseous envelope of any globe, whether by the absorption or condensation, or by the disengagement of any gas or vapor

* Ibid, pp. 59–67.

by the laws of diffusion and static equilibrium, be felt
ʳhere throughout the universe.
precipitation of water at the surface of a cooling globe,
s chemical or mechanical fixation there, would thus
sh the proportion of gaseous water throughout all space.
ːygen liberated in the growth of terrestrial vegetation
be shared with the remotest spheres, while the condensa-
carbonic dioxide at the surface of our own or any other
would not only bring in a supply of this gas from the
heres of other bodies, but by reducing the total amount
vould diminish, *pro tanto*, the barometric pressure at the
of this and of all other worlds.
hypothesis here advanced is not wholly new. Sir
m R. Grove, in 1842, suggested that the medium of light
at may be "a universally diffused matter," and subse-
y, in 1843, in his celebrated Essay on the Correlation of
al Forces, in the chapter on Light, concludes, with regard
atmospheres of the sun and planets, that there is no
why these atmospheres "should not be, with reference
other, in a state of equilibrium. Ether, which term we
pply to the highly attenuated matter existing in the
anetary spaces, being an expansion of some or all of these
heres, or of the more volatile portions of them, would
rnish matter for the transmission of the modes of motion
we call light, heat, etc., and *possibly minute portions of
mospheres may, by gradual accretions and subtractions, pass
lanet to planet, forming a link of material communication
the distant monads of the universe.*" Subsequently, in
dress as President of the British Association for the
cement of Science, in 1866, Grove further suggested
is diffused matter might become a source of solar heat,
ch as the sun "may condense gaseous matter as it
in space, and so heat may be produced."
bold speculation of a universally diffused matter, con-
g an interstellary medium, though thus repeatedly in-
upon by Grove, has passed almost unnoticed. It seems
e been unknown to Mr. W. Mattieu Williams, who in
ublished his very ingenious work entitled "The Fuel of
n,"* which is based on a similar conception, without
in support of it the high authority of Grove. The solar
ccording to Williams, is maintained by the sun's con-
ion of the attenuated matter everywhere encountered by
ody in its motion through interstellary space. The
ar movements impressed upon the sun by the varying
ions of the planets, stirring up and intermingling the

* also Williams on The Radiometer and its Lessons, Quart. Jour. Science, '6.

different strata of the solar atmosphere, and producing the great perturbations therein of which the telescope affords evidence—are, in his hypothesis, the efficient agents in this process. The diffused matter or ether, which is the recipient of the heat-radiations of the universe, is thereby drawn into the depths of the solar mass; expelling thence the previously condensed and thermally-exhausted ether, it becomes compressed, and gives up its heat, to be, in turn, itself driven out in a rarified and cooled state, and to absorb a fresh supply of heat, which he supposes to be in this way taken up by the ether, and again concentrated and redistributed by the suns of the universe. (Loc. cit., chap. v.)

Neither Grove nor Williams has considered the hypothesis of an interstellary medium in its geological relations. Dr. P. Martin Duncan, however, in his address as President of the Geological Society of London, in May, 1877, without noticing the priority of Grove, has adopted it from Williams,* but instead of supposing, with these, that the atmospheres of all bodies are in equilibrium, conceives the sun, in virtue of its greater mass, to be slowly attracting to itself the earth's terrestrial envelope. He thence proceeds to deduce therefrom important geological considerations, maintaining that from the greater height of the terrestrial atmosphere which, according to this view, must have prevailed in former ages, there would have resulted a higher temperature at the earth's surface, more aqueous vapor, and a more equable climate. From a more abundant precipitation would also follow greater sub-aerial denudation, while the formation of ice, though it might occur in elevated regions, would be impossible at or near the sea-level.

The correctness of all these deductions by Duncan from the condition of a denser terrestrial atmosphere appears to be indisputable, and, as we shall endeavor to show in the sequel, they are in harmony with the geological record. But, while admitting that changes in the earth's atmosphere conducing to such results have taken place, we maintain, in accordance with the principles already laid down, that these changes have not been due to solar attraction and absorption, but to the chemical and mechanical processes going on at the surface of the earth and other bodies in space, whereby the atmospheric elements are condensed in the forms of liquid and solid water, or fixed as hydrates, oxides, carbonates and hydrocarbonaceous matters.

The changes which have thus been produced in the terrestrial atmosphere are, by our hypothesis, reduced in amount by being shared with other worlds, and the consequences which

* It is due to my friends, Mr. Williams and Dr. Duncan, to say that they have both, in conversation, informed me that they were ignorant of the priority of Sir William Grove. The conception appears to have been original and independent in the mind of Mr. Williams.

Ebelmen, and others after him, have deduced with regard to the temperature of the earth's surface in former geological periods, would seem, at first sight, to be invalidated. Tyndall, however, in 1861, from a consideration of the great power of absorbing heat possessed alike by aqueous vapor and by certain gases, such as carbonic dioxide, and the consequent effects of small quantities of these in the atmosphere on terrestrial radiation, and thus on climate, was led to remark, "it is not therefore necessary to assume alterations in the density and height of the atmosphere to account for different amounts of heat being preserved to the earth in different times; a slight change in its variable constituents may have produced all the mutations of climate which the researches of geologists reveal."* Thus, although the amount of carbonic dioxide which, in past geological ages, has been, by chemical processes at the surface of our own and other worlds, abstracted from the universal medium, may not have sufficed to diminish by more than a small fraction the barometric pressure at the earth's surface, this change would still meet all the requirements of geological history, so far as temperature and climate are concerned. From this point of view, the suggestion of Tyndall assumes a weight and a significance not hitherto suspected.

We have thus briefly endeavored to show how the hypothesis of a universal atmosphere serves to explain certain chemical and physical facts in the history of our globe. To discuss it in all its bearings would require a volume. The climatic influences of a denser terrestrial atmosphere, or one of greater absorptive power than the present, have been indicated by Ebelmen, E. B. Hunt and Duncan, and, as we have seen, the gradual changes in the composition of the atmosphere imply a slow progressive diminution of the mean annual temperature of the earth's surface. This conclusion is in contradiction with the hypothesis of secular oscillations of the earth's temperature, due to astronomical causes, and giving rise to successive periods characterized by general glaciation, and leads us to interrogate on this point the geological record. We may inquire (1) whether, since the appearance of terrestrial vegetation, the mean annual temperature of the earth has ever been less, and (2) whether it has ever been greater than at present. It is clear from paleontological evidence that a very warm climate prevailed over the arctic regions during the Carboniferous, Triassic, Jurassic, and Lower Cretaceous periods, and that the refrigeration apparent in the Upper Cretaceous gradually augmented up to the Pliocene, the cold of which has continued till now, subject to certain variations in its distribution which are

* Tyndall, Bakerian lecture for 1861; L., E. & D. Phil. Mag., Oct., 1861, and Hunt, Chem. and Geol. Essays, pp. 42 and 46.

readily accounted for by changed geographical conditions. Such changes of sea and land are, however, inadequate to explain the elevated temperature which, according to the observations of Nordenskiöld, prevailed in the Carboniferous age, when the arctic climate permitted the development, over a great area of land, of a vegetation not unlike the Carboniferous flora of the inter-tropical regions. It is not easy to conceive that, with an atmosphere like that of the present time, any geographical conditions could maintain during the long polar winter the mild climate required for such a vegetation, even in insular regions, and still less over a continental area within the polar circle.

We are thus led to the conclusion that geographical changes, though adequate to explain the *greater refrigeration* of certain areas since the beginning of Pliocene time, are not sufficient to account for the *warmer climates* of previous ages, and to find the explanation of these in the different relations of the earlier atmosphere alike to solar and to terrestrial heat.

It is, however, obvious that, with such an atmosphere as we have supposed, the more elevated portions of the earth's surface might, as is now the case in inter-tropical lands, be lifted into regions where glaciation was possible, while a warm climate prevailed everywhere at the sea-level. Neither the glacial periods of more recent times, nor those of remoter geological ages, of which evidence is not wanting, necessarily depend upon any diminution in the earth's mean annual temperature at the sea-level. Glacial periods are, in this view, as has been well said by J. F. Campbell, not celestial, but local and terrestrial,* while, on the contrary, the warmer polar climates of Paleozoic and Mesozoic times are to be regarded as evidence of a generally elevated temperature at the earth's surface depending on atmospheric conditions, as already set forth.

In a note in the Comptes Rendus of the French Academy of Sciences, for Oct. 7, 1878, criticising my previous one of Sept. 23 "Sur les relations géologiques de l'atmosphere," already referred to at the beginning of this paper, Mr. Stanislas Meunier has argued in favor of the terrestrial origin of the atmospheric carbonic dioxide, the source of which he supposes to be a subterranean oxidation of a primitive store of carbon, a view which seems unsupported by any facts or analogies in nature. He opposes to the hypothesis which I have advocated, the fact of the absence of an atmosphere from the moon, while he asserts the existence of an abundant one around both Mercury and Venus. The evidences of such an atmosphere around the latter planet are well known, but the observations of recent

* Campbell on Glacial Periods; Quart. Jour. Geol. Soc., 1879, vol. xxxv, p. 98.

astronomers leave it doubtful, on the contrary, whether Mercury possesses a perceptible one, while, as regards our satellite, the conclusion, as stated by Newcomb, is that the lunar atmosphere, if it exist, is not equal to more than one four-hundredth that of the earth.

A little reflection will, however, show that the absence of any apparent atmosphere from the moon in no way militates against our hypothesis, since a completely refrigerated globe, such as our satellite must probably be, would long since have absorbed mechanically into its interstices, its share of the universal gaseous medium. It was many years since pointed out by Sæmann* that, as a consequence of the progressive refrigeration of our planet, the ocean and the air which surround it must one day disappear from its surface. The total volume of our atmosphere, at the density which it has at the sea-level, is, according to his calculation, less than four thousandths of that of the earth, the volume of the ocean being very much less. There is no known mass of cooled rock which has not a greater porosity than is represented by these figures, so that the conclusion seems inevitable that, with the complete refrigeration of the earth which must come in the course of ages, its atmosphere, following the ocean, will have so completely sunk into the pores of the cooled mass that its tension at the surface would be very small. Such a condition of things, Sæmann supposes to have been already attained in our satellite, a view which may be, with equal probability, extended to Mercury.

The hypothesis that interstellary space is filled with an attenuated matter which, in a more condensed form, constitutes the atmosphere and the waters of our own and other worlds, which we have already discussed in some of its chemical and geological bearings, assumes a new interest in connection with recent speculations as to evolution in the stellar universe. In considering the increasing chemical complexity revealed by the spectroscope in passing from nebulæ to white, yellow and red stars, Prof. F. W. Clarke, of Cincinnati, was led in 1873† to suggest the possibility of a generation of the higher from simpler forms of matter by a process of cosmical chemistry. A similar view was a few months later advanced by Mr. Lockyer, who reiterated and enforced these suggestions, showing that the chemical elements make their appearance in the cooling stars in the order of their vapor-densities—and moreover connected these considerations with the conjectures of Dumas as to the probably compound nature of the so-called

* Sur l'unité des phénomènes géologiques dans le système planétaire du soleil, Bull. Soc. Géol. de Fr., 1860–61, vol. xviii, p. 322, translated by the present writer for this Journal, II, xxxiii, p. 36.

† Popular Science Monthly, Jan., 1873, vol. ii, p. 32.

elements.* Mr. Lockyer has since extended this inquiry by his ingenious and beautiful spectroscopic studies, the results of which are embodied in his "Discussion of the Working Hypothesis that the so-called Elements are Compound Bodies," communicated to the Royal Society, Dec. 12, 1878.† In his first note, of 1873 (which is embodied in the later paper) he suggested that we see in the stars evidences of a *celestial dissociation* under the influence of intense heat, which, continuing the work of our furnaces, would break up the metalloids, and leave only the metallic elements of low equivalent weight which are found in the hottest stars. In his later memoir he further suggests that as there may be no superior limit to temperature, so of dissociation there may be no end.

With these may be compared the views enunciated by the present writer in a lecture before the Royal Institution, May 31, 1867, wherein, discussing the problems of stellar chemistry, he declared that the "dissociation of elements by intense heat is a principle of universal application," and with regard to the chemical elements, that their "further dissociation in stellar or nebulous masses may give us evidence of matter still more elemental than that revealed by the experiments of the laboratory, where we can only conjecture the compound nature of many of the so-called elementary substances."‡ In 1874, while discussing the speculations of Dumas, Clarke and Lockyer, he further suggested that the green line in the spectrum of the solar corona, which had been supposed to indicate a hitherto unknown element, may be a "more elemental form of matter, which, though not seen in the nebulæ, is liberated by the intense heat of the solar sphere, and may possibly correspond to the primary matter conjectured by Dumas, having an equivalent weight one-fourth that of hydrogen."§ Regarding this supposed element in the solar atmosphere, Prof. C. A. Young remarks that it must be of excessive tenuity, "a near relative, so far as gravity is concerned, to the luminiferous ether, and to the *Urstoff* of the German speculators."‖ In this connection it should be mentioned that Hinrichs, in 1866, put forth an argument¶ in favor of the existence of such a primitive matter or *Urstoff* from a consideration of the wave-lengths in the spectra of the various elements.**

* Comptes Rendus, Nov. 3, 1873.

† This Journal, III, xvii, 93-116; and farther, Clarke, Science News, Feb. 15, 1879, page 114.

‡ Reprinted from Proc. Royal Institution in Chem. and Geol. Essays, p. 37.

§ A Century's Progress in Theoretical Chemistry, by T. S. Hunt, being an address delivered on the Centennial of Chemistry, at Northumberland, Penn., July 31, 1874; Amer. Chemist, vol. v, pp. 46-51, and Pop. Science Monthly, vii, 420.

‖ This Journal, II, xlii, 350-368. ¶ This Journal, III, i, 319.

** Since these pages were in type my attention has been called to a paper read before the Literary and Historical Society of Quebec in January, 1870, by James

Lavoisier long since suggested that hydrogen, nitrogen and oxygen are, with heat and light, the simpler forms of matter from which all others are derived, and when it is considered that the first two of these are the only elements of which we have yet any certain evidence in the nebulæ, it will be seen that the speculation of Lavoisier is really an anticipation of that view to which spectroscopic study has led the chemists of to-day. The three elements named by him are those which, in the forms of air and watery vapor, make up nine hundred and ninety-nine thousandths of the atmosphere which, in accordance with our hypothesis, constitutes the interstellary medium. It was in view of all these considerations that the writer in 1874 ventured to say that "the nebulæ and their resultant worlds may be evolved by a process of chemical condensation from this universal atmosphere; to which they would sustain a relation somewhat analogous to that of clouds and rain to the aqueous vapor around us."* Such a speculation, which seeks for a source of the nebulous matter itself, is perhaps a legitimate extension of the nebular hypothesis.

Montreal, Feb. 14, 1880.

ART. XLIV.—*On the Archæan Rocks of the Wahsatch Mountains*; by ARCHIBALD GEIKIE, F.R.S., Director of the Geological Survey of Scotland, and Murchison Professor of Geology in the University of Edinburgh.

THE complete physical break between the crystalline schists and the overlying sedimentary groups in the Rocky Mountains and other ranges of the west has been clearly described by Gilbert, King, Hayden, Emmons and other writers. It is quite possible, however, that in these regions there may have been subsequent protrusions of granite and accompanying metamorphism; so that we ought not to decide that a mass is necessarily Archæan merely because it consists of schists and granites. Yet I am not sure that this assumption has not to a certain

Douglas, Jr., then President of the Society, and one of the Canadian Expedition to observe the total solar eclipse of August 7, 1869. Therein, while discussing the spectroscopic observations made during the eclipse, he refers to those of Professor Young, who had suggested a comparison between certain lines in the spectrum of the solar corona, and those observed by Winlock in that of the aurora borealis. With regard to these lines, Mr. Douglas then adds. "May they not therefore belong to some unknown element;—a gas, lighter than hydrogen, which, like the hypothetical ether, fills space?" To this he adds the suggestion that electricity both "in the auroral light of our own heavens, and the corona of the sun may render this hypothetical gas luminous." *Trans. Lit. and Hist. Soc. of Quebec*, New Series, part 7, p. 82.

* A Century's Progress, etc., cited above; also Chem. and Geol. Essays, preface to 2d Ed., p. xix.

extent influenced the observations of some of the able geologists to whom we owe our acquaintance with these western ranges. In a recent visit to the Wahsatch Mountains I was strongly inclined to doubt the correctness of the interpretation of the central and so-called Archæan portion of the chain given in the Reports of the Geological Exploration of the 40th Parallel. And I am disposed to offer the results of my visit for the consideration of those who are much more familiar than myself with the geology of that part of the United States.

Let me begin by expressing my unqualified admiration of the geological prowess shown by Mr. Clarence King and his associates, Messrs. Hague and Emmons, in their great survey. Having traveled over many hundreds of miles with their works in my hands I can bear testimony to their remarkably clear and accurate delineation of the broad geological features of the country. It is perhaps somewhat presumptuous in one who has only made a single journey through the region to offer any criticism of work which occupied years of continuous toil. Yet I am sure these writers, with the feeling of true scientific brotherhood, will themselves be the most desirous to give me a hearing, and will not require any assurance that my remarks are called forth by no spirit of fault-finding.

According to the Reports of the Exploration of the 40th Parallel, the Wahsatch Mountains consist of a central core of Archæan rocks, composed partly of granites and partly of various quartzite, schists, and other crystalline masses. These rocks are represented as having formed an island in the Paleozoic sea; and Mr. King asserts that the island must have presented to the west an almost precipitous face of 30,000 feet, or upwards of 5½ miles—an altitude exceeding that of any modern mountain chain.* Round this lofty Archæan island the whole of the Paleozoic and Mesozoic sediments are said to have been deposited to a depth of from 30,000 to 40,000 feet, in one continuous uninterrupted series. Subsequent terrestrial movements, acting along the line of the original island, have upraised the surrounding sedimentary masses, and the ancient crystalline rocks have once more been revealed by denudation.

Now the fact of the existence of a cliff more than 5½ miles high would require to be established by very carefully collected and convincing evidence. It was with very considerable curiosity therefore that I paid a visit to the Cottonwood district, where the evidence was said to be most complete. I must frankly own that I failed to observe any grounds on which the assertion appeared to me to be warranted. One would naturally expect that if a mass of strata 30,000 feet thick had been laid down against a steep slope of land, its component beds

* Geol. Exploration of 40th Parallel, vol. i, p. 124.

ıght to be full of fragments of that land. Each marginal belt, ›presenting an old shore-line, should be more or less conglom-·atic; at least, there ought to be occasional zones of conglom-·ate, just as at the present day, we have local gravel beaches n our shores. But I could find no trace of pebbles. It would f course be presumptuous in me to assert that they do not xist; but they are not mentioned by Mr. King, nor by Messrs. [ague and Emmons, and yet, as their evidence would be so nportant, we can hardly suppose that these writers observed ıem and made no reference to the fact.

But not only have no pebbles of the Cottonwood granite een recorded as occurring in the overlying Paleozoic rocks, it ı admitted that these rocks become metamorphosed as they pproach the granite. The natural inference to be drawn from ıese facts, one might suppose, would be that the granite is ıter in date than the rocks overlying it. Mr. King admits ıat the granite had been undoubtedly the center of local met-morphism, but this change he regards as "strictly mechanical nd not to be mistaken for the caustic phenomena of a chemi-ılly energetic intrusion." (p. 45). How he would discriminate etween a mechanical and chemical cause producing precisely ıe same ultimate effect he does not explain. Had he not been rmly convinced that all the granite must be Archæan he ·ould hardly, I venture to think, have penned that sentence. 'wo pages farther on he admits that round the granite mass ıe Carboniferous limestones have been invaded by igneous ikes, and these rocks (named granite-porphyry by Zirkel), he sserts to be "middle-age porphyries, not to be confounded ·ith the Archæan crystalline rocks." (p. 49). But why should ıey be "middle age," or rather on what grounds are we to ɜparate them from the neighboring granite? Not a single ɜason is given save the obvious one that when a geologist has ıade up his mind that a granite is Archæan he cannot of ɔurse admit that it sends out ramifications into overlying Pale-zoic rocks. Yet the natural tendency of any unbiased ob-ɜrver must, I should think, be to connect these surrounding ikes with the main granite mass inside. Curiously enough, [r. King himself, in another passage, admits that they are "in ll probability a dependence of the granite." (p. 46). But ırely the occurrence of intrusive dikes twenty feet broad enetrating limestones that have been converted into marbles ı something more than a "strictly mechanical" phenomenon. 'ne argument given by Mr. King for the antiquity of the ranite is that it does not send out dikes into the overlying ɔcks. (p. 48). But, as he himself is no doubt well aware, the eins or dikes which penetrate the rocks around a granite boss re not always themselves granite. They very commonly take ıe form of his "granite-porphyry."

I submit, therefore, that the facts taken by themselves and without reference to any preconceived opinion or theory, are these: 1st. A large mass of granite* on the Wahsatch Mountains ascends with an oblique or transgressive boundary line from certain schists and quartzites across the Paleozoic series up into the Upper Carboniferous horizons. 2d. The rocks as they approach the granite manifest increasing metamorphism; the limestones pass into white granular marble, and other rocks have assumed the character of schist. 3d. Among the Carboniferous limestones and other rocks around the main mass of granite, there occur, in different places, dikes or veins of granite-porphyry, like those usually met with in a similar position. The conclusion which I would draw from these facts is that the granite is intrusive, and is later in date than the Upper Carboniferous rocks which have been metamorphosed in contact with it. Mr. King speaks of there being possibly two granites, one metamorphic and one intrusive, but both of Archæan date. I could observe no reason for making any subdivision in the granite mass. The somewhat foliated arrangement in certain portions of the granite is not uncommon toward the periphery and even within the central portions of intrusive bosses.

The section across the Wahsatch range, placed below map No. III (east half) of the Geological Exploration of the 40th Parallel, seems to me to bear the strongest evidence against Mr. King's own reading of the structure of the mountains. If the granite there shown as underlying the highly tilted Paleozoic rocks be regarded as anterior in date to these rocks, as, in fact, the land surface against which they were laid down, the section, I submit, involves a series of physical impossibilities, or at least of such glaring improbabilities as to demand full and incontrovertible proof in its support. For, in the first place, it requires us to believe that the cliff against which the Paleozoic sediments were deposited, must have been *at least twelve miles* high! that being the horizontal length of the platform of granite into which the rocks dip. In the next place it necessitates the admission that this stupendous precipice was subsequently *turned over on its back*, carrying with it the adhering later rocks. In the third place, it demands an amount of denudation to which there would be no parallel anywhere in the region, for the highly tilted strata must then have been worn down till nothing but a cake of them was left upon the granite. If, however, this granite be younger than the overlying rocks, the section expresses sufficiently well the structure of the ground. That the latter is the natural interpretation of

* There can be little doubt that though partially interrupted at the surface by overlying formations it is really all one granite mass.

the section will, I feel sure, he admitted by any impartial geologist in whose hands the map is placed.

I venture to put forward these views with diffidence, and because it appears to me to be a matter of great importance not merely in regard to the geological structure of the West, but to questions in dynamical and physiographical geology, that the true structure of the Archæan nucleus of the Wahsatch Mountains should be correctly interpreted. Mr. King, in his great memoir, has treated that area as a kind of type, and has based upon it much of his speculation regarding the form of the Archæan land, and the nature and effects of subsequent fractures of the rocky crust. I confess that it was with considerable incredulity that I read in his interesting chapters reiterated assertions that the Archæan land was so stupendously mountainous, that some of its peaks rose more than 5½ miles into the air, and remained above water during the whole of Paleozoic and Mesozoic time. I asked myself how much loftier and broader these mountains must really have been at first to have been able to outlast such a vast period of denudation. For the dimensions assigned by Mr. King must on his own showing be a minimum, reckoned after all these ages of ceaseless waste. But if I am correct in regarding the Wahsatch granite as of post-Carboniferous date, then we are relieved from the uncomfortable incubus of these primeval mountains. We are not required to believe in the existence of a cliff 5½ miles high, which maintained its position and steepness during the greater part of all geological time. And we are spared the necessity of a colossal fracture of 30,000 feet on the west side of the Wahsatch Mountains. The view which I am inclined to adopt regarding the structure of this range differs from that proposed by Mr. King; and perhaps I may be permitted to communicate it on another occasion in the pages of this Journal.

ART. XLV.—*Analyses of some Apatites containing Manganese*; by SAMUEL L. PENFIELD. (Contributions from the Sheffield Laboratory of Yale College, No. LIX.)

IN their description of the mineral locality at Branchville, Conn. (this Journal, July, 1878), Messrs. Brush and Dana mention the occurrence of a green manganiferous apatite accompanying the other manganese minerals. Apatite occurs there of many shades of color, from those which are white and transparent to those which are dark green, and still others of a bluish shade. The green varieties occur in flat crystalline

masses imbedded in feldspar; occasionally the form of the short prism is distinct. The white variety is usually in crystals; these crystals are short prisms combined with the pyramidal and rough pinacoid planes. The prismatic planes have a fibrous appearance, although they are polished and very smooth, and the pinacoids are found on close inspection to give numerous reflections from their surfaces, when looked at obliquely and turned, showing that the crystals are made up of bundles of minute hexagonal prisms of the same length, each with a small pyramidal termination. There have also been found there a few transparent and very highly modified crystals. All the varieties examined contain manganese, as the following analyses will show.

I was led by the discovery of manganese in the apatite from Branchville, to examine the same mineral occurring at Franklin Furnace, New Jersey; manganese was also found to be present in it. This apatite occurs in crystals of a light apple-green color imbedded in calcite, from which they are readily separated.

The material employed in the four analyses, given below, was as follows:—Analysis 1 was made of a dark green variety from Branchville, the darkest that was found. It has a vitreous luster, appearing black by reflected light, but a beautiful dark green by transmitted light. Only clear transparent fragments were accepted.

Analysis 2 was made in the Sheffield Laboratory by Mr. Frederick P. Dewey, of a green variety from Branchville, lighter in color than the one just described. Analysis 3 was of the white crystallized variety from Branchville. Great care was taken to select only the crystals which have been described before as having the rough pinacoid planes. Analysis 4 was made of the crystallized variety from Franklin Furnace, N. J. The whole amount employed was taken from one large crystal. It readily separated from the calcite in which it was imbedded, and although the analysis shows the presence of carbonic acid, it was from no external admixture of calcite.

No. 1. *Specific gravity*, 3·39.

	I.	II.	Mean.	Ratio.		
P_2O_5	41·60	41·66	41·63	2·93		1
Fe_2O_3	·77		·77			
CaO	40·31		40·31	·720	·869	2·97
MnO	10·59		10·59	·149		
Ca			3·29	·082		·28
F	3·20	3·04	3·12	·164		·56
Cl	·03		·03	·000		
			99·74			

No. 2, by Mr. F. P. Dewey.

	I.	II.	Mean.	Ratio.		
P_2O_5	40·94	40·99	40·96	·288		1
Al_2O_3	·52	·47	·50			
Fe_2O_3	·09	·08	·08			
CaO	47·79	47·95	47·87	·855	·890	3·09
MnO	2·50	2·47	2·48	·035		
Ca			4·04	·101		·35
F	3·84	3·84	3·84	·202		·70
Insoluble	·06	·05	·06	·000		
			99·83			

No. 3. Specific gravity, 3·144.

	I.	II.	Mean.	Ratio.		
P_2O_5	41·47	41·47	41·47	·292		1
Fe_2O_3	·22	·22	·22			
CaO	49·10	49·13	49·12	·877	·905	3·01
MnO	1·98	1·94	1·96	·028		
Ca			2·88	·072		·25
F	2·68		2·68	·141	·144	·49
Cl	·10		·10	·003		
Insoluble	1·50		1·50			
			99·93			

No. 4. Specific gravity, 3·22

	I.	II.	Mean.	Ratio.		
P_2O_5	39·58	39·59	39·59	·279		1
Al_2O_3	·56	·56	·56			
Fe_2O_3	·77	·77	·77			
CaO	46·52	46·76	46·64	·833	·852	3·05
MnO	1·38	1·31	1·35	·019		
ZnO	·03	·03	·03			
Ca			3·57	·089		·32
F	3·40	3·34	3·37	·177	·178	·64
Cl	·04		·04			
$CaCO_3$	2·82		2·82	·001		
H_2O	·52		·52			
			99·26			

ıe above ratios coincide very nearly with that required by e accepted formula of the species, viz: 1 : 3 : 0·33 : 0·67.

These analyses are the first that show the presence of notable .antities of manganese replacing calcium in apatites. It is ю to be noted that these apatites are essentially fluor-apatites ntaining only a trace of chlorine.

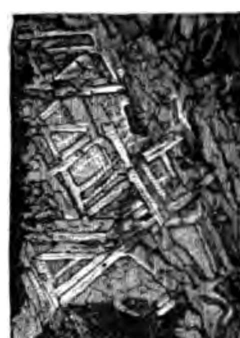
In closing, I wish to express my thanks to Professor George Brush, who has kindly provided me with the material for :rying on this investigation, and to Mr. Frederick P. Dewey, ıose analysis I have quoted.

Art. XLVI.—*An account of the finding of a new Meteorite in Cleberne County, Alabama;* by W. E. Hidden.

When in eastern Alabama, during last autumn, carrying forward some mineralogical investigations in the interest of Mr. Thomas A. Edison, I learned from Ex-Governor W. H. Smith of Wedowee, of the existence of a supposed mass of native iron, which he believed might perhaps be a meteorite. The account which he gave me of it, in his own words, is as follows: "Sometime in 1873, while the Rev. John F. Watson was plowing on a newly cleared piece of land, near Chulafinnee, in Cleberne county, Ala., he turned up a heavy mass of metal. He supposed it to be a rich specimen of bog iron ore, which exists in considerable quantity in the vicinity, and took the mass home. Some days later he carried it to the village blacksmith to have it tested. After heating one corner in the

1.

2.



forge, a piece of about 3¼ lbs. was cut off and wrought into horseshoe nails and a point for a plow. The fact of its malleability tended to set at rest the various local theories about the origin of the mass, and it was there agreed to be a specimen of native iron. The mass was then deposited in the office of the Noble's Brothers' Iron Works at Anniston, Alabama, and remains there now unsuspected of being a meteorite, and will in all probability get into the furnace sooner or later."

Through the kindness of Governor Smith, the specimen was secured and forwarded to me. On January 21st, 1880, it was

ceived at Menlo Park, N. J., and was at once recognized as an
ɔn meteorite. A letter from Mr. Watson informs me, further, at the mass was originally thickly encrusted with scales of st of a red-brown color, and which fell off while being heated the forge.

It now weighs 32½ lbs. (= 14·75 kg.), is somewhat triangu-r in shape (see cut); its three diameters being about 25^{cm}; average thickness 6^{cm}.

An analysis by J. B. Mackintosh, E. M., shows it to be of e usual iron-nickel alloy variety, with small percentages of pper, phosphorus and carbon.* The Widmannstättian fig-es are well developed on this iron. They are shown in figure which is of exact natural size. This meteorite is one of ree discovered by the writer in the Southern States last ar. Descriptions of the others will be given later.

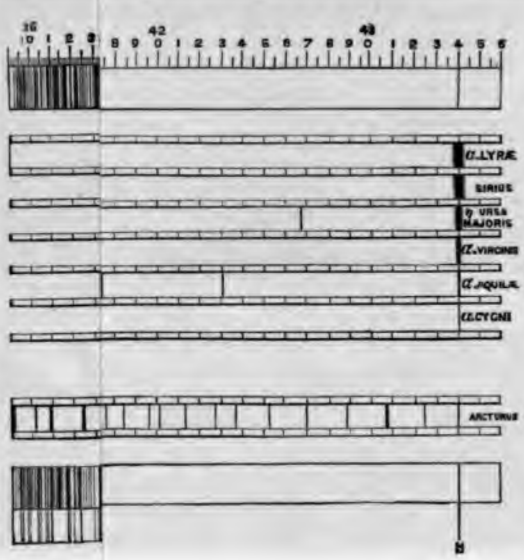
January 29th, 1880.

RT. XLVII.—*On the recent formation of Quartz and on Silicification in California*; by T. STERRY HUNT.

AT the meeting of the American Institute of Mining Engi-ers in New York, Feb. 19, 1880, Professor George W. Mayn-d exhibited a remarkable specimen lately obtained by him m the mines of the Gold Run Hydraulic Co. at Dutch Flat California. It consisted of a mass of milky vitreous quartz, which a recent fracture had disclosed an imbedded fragment, out half an inch in diameter, of the characteristic so-called e *gravel* of the region, holding in its paste a worn and rounded ece of gold of several grains, weight. Portions of a similar ue gravel adhered closely to certain parts of the mass of artz. Remarks were made on this specimen by Professors Iliman and Egleston, and by Dr. T. Sterry Hunt, all of whom, ter examination of it, were satisfied of the correctness of the inion expressed by Professor Maynard, that the quartz had ade part of a vein formed in the auriferous gravel subsequent the solidification of the latter.

* The analysis is now being made in duplicate, and when completed will be blished in this Journal. W. E. H.

† This communication, which for want of space was excluded from the April mber, had been printed and revised before the writer had seen Professor Joseph Conte's paper on The Old River Beds of California, in the March number of this urnal, where (on pages 179–181), he has so well described the auriferous gravels re referred to, and pointed out the true relations between the blue gravel and the per and altered portions of the deposit. As regards the process of silicification, is not, I think, necessary to suppose the infiltration of alkaline waters from the erlying volcanic rock. to explain the solution of silica. As elsewhere pointed t by the writer (page 350 of the present volume), the removal of the silica in a luble form from the silicates which make up a large part of the gravel itself, es not require the intervention of alkalies. T. S. H.


α LYRÆ
SIRIUS
η URSA MAJORIS
α VIRGINIS
α AQUILÆ
α CYGNI
ARCTURUS

The photographs were examined and the lines measured by means of a micrometer attached to a microscope of low power. These measures were reduced to wave-lengths by the help of solar and terrestrial spectra, use being made of M. Cornu's map of the ultra-violet part of the spectrum, and of M. Mascart's determination of the wave-lengths of the lines of cadmium.

Photographs have been obtained of the stars Sirius, Vega, α Cygni, α Virginis, η Ursæ Majoris, α Aquilæ, Arcturus, β Pegasi, Betelgeux, Capella, α Herculis, Rigel, and α Pegasi. Also of the planets Jupiter, Venus, and Mars, and of different small areas of the moon.

The spectra of Sirius, Vega, α Cygni, α Virginis, η Ursæ Majoris, α Aquilæ and Arcturus are laid down in the map on the scale of M. Cornu's map of the ultra-violet part of the solar spectrum.

The stellar spectra extend from about G to O in the ultra-violet.

Six of these spectra belong to stars of the white class. In 1864 the author pointed out the features in common in the visible spectra of these stars. These photographs present a remarkable typical spectrum consisting of twelve strong lines (seven only of these were given in the preliminary note in 1876). The least refrangible of these is coincident with the hydrogen line (γ) near G. The second with *h*, also a line of hydrogen. The third with H. K, if present at all, is thin and inconspicuous.*

These lines, H and K, are coincident with lines in the calcium spectrum, and are usually attributed to the vapor of this substance. Now there is another pair of strong lines in the spectrum of calcium, which in M. Cornu's map have the wave-lengths 3736·5 and 3705·5. There are no strong lines in the white stars coincident with these lines. A glance at the map will show how remarkable is the arrangement in position of these twelve typical lines. They form a great group in which the distance between any two adjacent lines is less as the refrangibility increases. It is at once suggested that they are connected with each other and represent probably one substance, and two at least belong to hydrogen.

It should be stated that the continuous spectrum extends in the photographs beyond S, but no lines can be detected beyond the twelfth line at λ 3699. For the sake of convenience of reference the author distinguishes these lines by the letters

* The author refers to Mr. Lockyer's paper, *Proceed. R. S.*, No. 168, 1876, in which he suggested that photographs of the spectra of the brighter stars might show modifications of this character of the lines of the calcium spectrum, and that such modifications would confirm his views on the dissociation of this substance. Reference is also made to *Proceedings R. S.* December, 1878, fig. 1, where Mr. Lockyer gives a fuller statement of his views on this and other points in connection with different classes of spectra of the stars.

of the Greek alphabet in the order of refrangibility, beginning with the first line beyond K of the solar spectrum. The wave-lengths of these lines are as follows:—

Hydrogen near		Hydrogen near	
1. G	4340	7. δ	3767·5
2. h	4101	8. ϵ	3745
3. H	3968	9. ζ	3730
4. α	3887·5	10. η	3717·5
5. β	3834	11. θ	3707·5
6. γ	3795	10. ι	3699

In all these stars the line K is either absent or very thin as compared with its appearance in the solar spectrum.* In the spectrum of Arcturus, which belongs to the solar type, this line exceeds in breadth and intensity its condition in the solar spectrum. The white stars may, therefore, be arranged in a series in which the line K passes through different stages of thickness, at the same time that the typical lines become narrower and more defined, and other finer lines present themselves in increasing numbers. Arcturus seems to present a spectrum on the other side of that of the sun in the order of changes from the white-star group.

The spectra of the planets were taken on the plan suggested by the author in 1864, in which the planet's spectrum is observed or photographed together with a daylight spectrum. These photographs show no sensible planetary modification of the violet and ultra-violet parts of the spectrum of the planets Venus, Mars, and Jupiter.

Numerous spectra of small areas of the lunar surface have been taken under different conditions of illumination, and during eclipses of that body. The results are wholly negative as to any absorptive action of a lunar atmosphere.

The author is preparing to attempt to obtain by photography any lines which may exist in the violet and ultra-violet spectra of the gaseous nebulæ. He also points out the suitability of the photographic method of stellar spectroscopy, first inaugurated by his researches, to some other investigations, such as—differences which may present themselves in the photographic region in the case of the variable stars, the difference of relative motion of two stars in the line of sight, the sun's rotation from photographic spectra of opposite limbs, and the spectra of the different parts of a sun-spot.

In the hope of throwing light on many physical questions suggested by the stellar photographs, the author has taken for comparison a number of terrestrial spectra, especially of hydrogen and calcium, under different physical conditions. As he is still pursuing this inquiry, he reserves an account of this part of his work.

* Messrs. Dewar and Liveing have found in their experiments similar relative changes of intensity of the lines of calcium corresponding to H and K in the *emission* spectrum of calcium.

Art. XLIX.—*The Uranometria Argentina.*

It is now nearly ten years since Dr. Gould arrived in Buenos Ayres on his way to Cordoba, under appointment by President Sarmiento to establish there a national observatory for the Argentine Confederation. It was more than two years after his arrival before he was able to mount his meridian circle and begin regular observations with it. This interval was not allowed to run to waste, and Dr. Gould began a series of observations with the purpose of doing for the southern stars what Argelander had done so well thirty years before, in the *Uranometria Nova*, for the stars of the northern sky.

Th results of this undertaking are now published in a quarto volume of 385 pages, and an atlas of 14 large maps of stars. The Uranometria Argentina will probably always be the standard of reference for the southern stars visible to the naked eye. Any information about it will therefore be acceptable to the readers of the Journal.

The quarto volume is printed in parallel columns of Spanish and English. It forms the first volume of the *Resultados del Observatorio Nacional Argentino.* It is beautifully printed by Coni at Buenos Ayres.

It consists of eight chapters. The first contains the history of the work. In the second, on *Standards of Magnitude*, Dr. Gould explains the several steps in forming standards for a symmetric and continuous series of gradations of brilliancy expressed in tenths of magnitudes, such that the round units themselves should coincide as nearly as possible with those of Argelander in his *Uranometria Nova.* A zone of stars 10° in breadth was selected, whose altitude was the same at Bonn and at Cordoba, in which 722 stars were selected as types. This series of standards was, in the end, minutely compared with the corresponding determinations of Argelander, and those of Heis in his *Atlas Coelestis Novus*, also with the magnitudes given in the *Durchmusterung* and in the zones of Lalande and Bessel. Some of the stars had been observed at Albany by Dr. Gould in 1858. A table of these type stars is given with their magnitudes as stated by these several authorities. For stars brighter than the sixth magnitude, the adopted scale ranges lower by an insignificant amount than that of the Uranometria Nova. Dr. Gould's comparisons of scales of magnitude in this chapter and in the fourth chapter are entirely independent of the like elaborate comparison by Professor C. S. Peirce in the ninth volume of the Annals of the Harvard Observatory.

The third chapter is devoted to the constellations and their

nomenclature. It opens with a history of what was done by Bayer, who first broke away from the traditional catalogue and figures of Ptolemy, by Lacaille, Bode, Sir John Herschel, Baily and others in their attempts to arrange the stars of the southern sky in constellations, and give the stars distinctive names in them. The principles which Dr. Gould has finally acted upon are expressed in six rules.

The first of these is that the constellations of Ptolemy and Hevelius, together with those adopted or introduced by Lacaille, are to be retained, and no others. *Argo* disappears *nominally*, being replaced by *Carina*, *Puppis* and *Vela*.

The other rules refer principally to the names of the stars and the constellations, except the third, which is perhaps the most important.

"The boundaries must be so arranged that the constellations shall include all stars denoted by Greek letters which were assigned to them by their authors (unless such arrangement has been superseded by later accepted authority), together with all others as bright as the sixth magnitude, which are referred to them by general usage. The boundary lines are to be formed, wherever possible, by meridians of right-ascension and parallels of declination for the mean equinox of 1875·0. When this is not feasible they should consist of regular curves as near as may be to great circles, and their positions be defined by points of intersection with meridians and parallels."

Dr. Gould has described boundaries for the several constellations up to the parallel of 10° of N. Declination, where the catalogue terminates. In approaching this limit he says that he has kept in mind the possibility of some future attempt to establish an analogous system in the northern hemisphere, and adds that this is clearly not to be thought of at present, but may at some not distant day be regarded as desirable.

The notation adopted for the stars in each constellation is given at length in the carefully prepared notes to the several constellations.

This fixing of the boundaries of the constellations, in the southern sky, is a subject of great importance. Would it not be well for the *Astronomische Gesellschaft*, or some other authority in astronomy, to consider Dr. Gould's boundaries, and, if they are approved, urge their acceptance by all astronomers?

The fourth chapter explains the determination of the magnitudes of the stars from those of the type belt, and gives a comparison of the magnitudes adopted with the magnitudes of Argelander, Heis, Lacaille, Behrmann, Lalande, Bessel and Herschel.

The fifth chapter contains the catalogue of the stars arranged by constellations. Only those stars are included that are

brighter than 7·1 magnitude, and are within 100° of the south pole, in all 7780 in number. The stars bear current numbers, in order of R. A., and the synonym in other catalogues, and the magnitude, together with the R. A. and declination are given for each star. Of the number mentioned, 6783 belong to the southern heavens, and 997 to the belt of 10° in width, north of the equator. They belong to 66 different constellations.

About 100 pages are occupied with the sixth chapter, which contains notes to the catalogue. Most of these are devoted to the magnitudes of stars, with special reference to their being possibly variable. This property of variability Dr. Gould believes to be much more frequent than has been hitherto supposed.

Chapter VII describes the atlas, which "consists of thirteen special charts, together with a fourteenth or general one, which presents at a single view the whole region included in our work, and serves as an index map both for the others and for the constellations."

These charts are drawn upon the stereographic projection, and correspond to a sphere having a radius of one meter. The stars are represented by circular black dots, having their areas proportional to their respective amounts of light; and upon the map there is given a scale to half magnitudes, but the actual drawing shows the separate stars to a nearer approximation.

"The names and distinguishing letters of the stars have been omitted, and the names of the constellations been placed in a compact form in those positions least likely to distract the attention of the observer" in order to have the real aspect of the sky as nearly reproduced as possible.

The practical inconvenience entailed by this condition of not having the stars' letters given in the first thirteen charts, is lessened by having the principal ones lettered in Chart XIV.

The charts themselves are sumptuously lithographed on heavy paper and in excellent style throughout. Perhaps nowhere is the artistic skill of the lithographer, Mr. Julius Bien, better shown than in the beautiful representation he has given of the Milky Way. Dr. Gould, after referring to the labor expended on the mapping of this part, goes on to say, "To astronomers dwelling near the level of the sea, or in the neighborhood of large cities, or where, for any other reason, the meteorological conditions are not especially favorable to transparency in the atmosphere, the brilliancy of the Milky Way as here depicted may seem excessive. But this is not so in any of those impressions which I have personally examined; none of them exaggerating in general its brightness as seen at Cordoba under favorable circumstances."

Chapter VIII, which is a dissertation on the distribution of stars (occupying 35 pages), opens with a table showing "the nber of stars, of each grade of brilliancy from $7^m \cdot 0$ upward, ich are to be found south of the parallel of ten degrees north lination." The results of this table are:—

Magnitude.	No. Stars South Declination.	No. Stars North Declination.
0·0 to 2·0	19	3
2·1 to 3·0	66	6
3·1 to 4·0	166	29
4·1 to 5·0	321	55
5·1 to 6·0	1238	174
6·1 to 7·0	4884	724

'utting Σ_m to represent the total number of stars contained he catalogue to the *m*th magnitude inclusive, he finds

$$\Sigma_m = 0 \cdot 54896\ (3 \cdot 9111)^m$$

oe a near approximation to the number of stars of each magnide contained within the limits. Then follows a careful and newhat elaborate comparison between the numbers of stars igned to the several magnitudes in the Durchmusterung, the anometria Nova and the Atlas Coelestis of Heis. Dr. Gould ns up the result of his extremely interesting investigation 368) as follows:

'1. There is in the sky a girdle of bright stars, the medial e of which differs but little from a circle, inclined to the actic circle by a little less than 20°.

2. The grouping of the fixed stars brighter than $4^m \cdot 1$ is more tematic, relatively to that medial line, than to the galactic cle; and the abundance of bright stars in any region of the y is greater as its distance therefrom is less.

3. The known tendency to aggregation of faint stars toward Milky Way is according to a ratio which increases rapidly their magnitudes decrease, and the law of which is such that corresponding aggregation would be scarcely, if at all, pertible for the bright stars.

4. These facts, together with others which have been stated, icate the existence of a small cluster, within which our sysn is eccentrically situated, but which is itself not far from middle plane of the galaxy. This cluster appears to be of attened shape, somewhat bifid, and to consist of somewhat re than 400 stars, of magnitudes from the first to the seventh, ir average magnitude being about 3·6 or 3·7.

5. The general distribution of the fixed stars according to gnitude does not appear capable of being well represented any simple algebraic expression. Yet by adopting the data the preceding paragraph, and supposing the several magniles of the stars in the cluster to follow the law of Probabili-s, we obtain for each class of magnitudes a number, which

being subtracted from the observed number in the sky, leaves a system of distribution which may be represented by the expression $\Sigma_m = ab^m$ within the limits of the errors of observation.

6. The accordance thus obtained holds good for the stars of both hemispheres down to the lowest limits of magnitude for which trustworthy enumerations exist; and this whether we employ the numbers of the Durchmusterung, of Argelander's and Heis's Uranometries, or of this present work.

7. The form of the expression $\Sigma_m = ab^m$ is that which corresponds to the hypothesis that in general the stars are distributed at approximately equal distances from one another, and are of approximately equal intrinsic brilliancy. It is, however, not requisite for its applicability that their distribution be equable in all directions, but only that their number be proportional to the volume of the spherical shell within which they are contained.

8. Each of the authorites, and each hemisphere, affords data from which results essentially the same value for the ratio b, the difference in the data being in every case, represented by differences in the coëfficient a. The value thus obtained for b, corresponds to the light ratio 0·4028 for descending, or 2·4827 for ascending, magnitudes."

Then follows a description of the parts of the Milky Way, with its rifts and ramifications, and the gradations and contrasts of light. With this is a careful determination of the medial points and the breadth of the stream, the position of the galactic circle, and the numbers of stars on the two sides of the circle.

"Inferences of some cosmological importance are deducible from the tables just given. It cannot escape notice that the part of the Milky Way which lies between 160° and 225° of galactic longitude, or from 6^h to 8^h of right-ascension, is much the broadest of all; this corresponding to the region of widest separation of the branch-circles in the undivided portion of the stream. Moreover the narrowest parts are from 3^h to $5\frac{1}{2}^h$ and from $10\frac{1}{2}^h$ to 12^h of right-ascension, or, roughly, in the galactic longitudes 105° to 150° and 255° to 270°. These regions, which are also of preëminent brilliancy, correspond approximately to the place where the circles of the branches intersect each other; in short, there are sundry indications that the whole phenomenon of the Milky Way may become simplified by treating it as the resultant of two or more superposed galaxies."

H. A. NEWTON.

ART. L.—*On the Ivanpah, California, Meteoric Iron;* by CHAS. UPHAM SHEPARD, Emeritus Professor of Natural History in Amherst College.

FOR my knowledge of the discovery of this meteorite, I am indebted to Mr. C. C. Parry, of the Academy of Science of Davenport, Iowa, and to Mr. W. G. Wright, Naturalist at San Bernardino, California, from each of whom I received a few weeks ago, communications upon the subject, accompanied by small fragments from the mass, for my examination and analysis.

Before proceeding to the description of these, I may state the circumstances connected with this interesting discovery. The locality is situated in a region known as the Colorado Basin, within eight miles of Ivanpah, which place is about two hundred miles northeast of San Bernardino in Southern California.

The mass was discovered very recently by Mr. Stephen Goddard, who in returning one evening to his camp after a prospecting excursion, as he was crossing what is there called a *wash*, had his attention arrested by a singular looking bowlder. On striking it with his pick, he was still more surprised at the ringing sound produced by the blow. These observations led him to return the day following with a wagon, and to remove it to Ivanpah. From thence it was taken by Mr. Heber Huntington to San Bernardino, where it was placed for some time on exhibition at the store of Mr. Craig. From thence again, it has lately been transported to San Francisco, and deposited with Mr. Henry G. Hanks, the State Geologist; and will, in all probability, be preserved in the future geological collection of California.

Description of the Meteorite.

It is oval in shape, having one of its sides somewhat flattened. Its surface is entirely covered with depressions or dents, "as if it had been patted all over with pebbles" or clam shells, while yet soft or plastic. The size and shape of these concavities are various, from one to four inches across; and in addition, there are three round holes an inch deep as if made by the little finger.* The weight of the mass is supposed to be one hundred and twenty pounds. Its dimensions are fourteen inches in length, by nine in breadth and seven in thickness.

The fragments in my possession (the largest weighing five grams) show a highly crystalline and homogeneous iron, requir-

* From this account, it would appear that the mass resembles the Orange River (South Africa) iron of 170 pounds weight in the Amherst College cabinet, which singularly enough has one of the finger-holes above noticed, which though not so deep, is as perfectly turned at sides and bottom, as if artificially formed.

ing no aid of etching to reveal the Widman figures; and prove, that it must belong to the order Megagrammic of my class of Siderites. Indeed it seems highly probable, that the crystalline structure of the entire mass is in conformity with that of a single individual. The cleavages, as most usual in these bodies, are octahedral; and reveal rather a coarse lamination. The schreibersite separating these thick laminæ (as brought into view by polishing and etching) is very thin; and runs in perfectly straight lines, dividing the polished surfaces off into rather broad, triangular and oblique angled spaces, whose areas again, are beautifully covered by very small irregular dots and characters, themselves distributed in parallel rows, but among which, continuous straight lines appear to be wanting,—the boundaries of the larger, triangular and quadrangular spaces only, consisting of rectilinear lines. There would therefore seem to be two varieties of schreibersite present; one in flat leaves, the other in wavy, semi-cylinders or irregular prisms. The latter may be the rhabdite of Reichenbach. Both kinds, however, are equally taken into solution by long digestion in aqua regia. Specific gravity = 7·65.

Composition.

Iron	94·98
Nickel	4·52
Phosphorus	0·07
Graphite	0·10
	99·67

No sulphur was present. For want of material, no examination was made for the metals, often detected in small quantities in meteoric irons.

Charleston, S. C., March 12, 1880.

ART. LI.—*The Atomic Weight of Antimony: Preliminary Notice of Additional Experiments;* by JOSIAH P. COOKE.

[From the Proceedings of the American Acad. of Arts and Sci., Mar. 10, 1880.]

IN our previous paper on this subject,* we gave our reasons for the opinion, since fully confirmed, that the bromide of antimony is the most suitable compound of this element, as yet known, for determining its atomic weight; and the results of fifteen analyses of fiv different preparations of the bromide were published, which gave for the atomic weight in question the mean value 120·00 with an extreme variation between 119·4 and 120·4 for all the fifteen analyses, and between 119·6

* This Journal, III, xv, 41, 107, 1878.

and 120·3 for the six determinations in which we placed most confidence. The antimonious bromide used in these determinations was purified first by fractional distillation, and secondly by crystallization from a solution in sulphide of carbon. In the crystallized product thus obtained, the bromine was determined gravimetrically as bromide of silver in the usual way. Although it seemed at the time that the results were as accordant as the analytical process would yield under the unfavorable conditions, which the presence of a large amount of tartaric acid in the solution of the bromide of antimony necessarily involved; yet it was obvious that the agreement was far from that which was desirable in the determination of an atomic weight, and our chief confidence in the accuracy of the mean value—independently of its remarkable agreement with previous results—was based on the fact that the known sources of error tended to balance each other. Hence our conclusions were stated with great caution, and the hope was expressed that after a more thorough investigation of the subject we might be able "to return to the problem with such definite knowledge of the relations involved as will enable us to obtain at once more sharp and decisive results than are now possible." Unfortunately this investigation has been delayed by causes beyond our control.

In our previous paper, we described a simple apparatus which we devised for subliming iodide of antimony; and in a note to the paper we stated that we were applying the same process to the preparation of the bromide of antimony, and that it promised excellent results. Our expectations in this respect have been fully realized, and the product leaves nothing to be desired either as regards the beauty or the constancy of the preparation. The fine acicular crystals are perfectly colorless, and have a most brilliant silky luster. With ordinary precautions they can be kept indefinitely without change, and it is easy therefore to determine the weight of the material analyzed to the tenth of a milligram.

We have carefully studied the causes of error involved in the analytical process of determining bromine in an aqueous solution of bromide of antimony and tartaric acid by the usual gravimetric method. These causes we propose to discuss in a future more extended paper. In this preliminary notice, we have only space to state that we have satisfied ourselves that the small differences between the results previously obtained arose wholly from the analytical process, and not from any want of constancy in the material analyzed; and further that these sources of error are to a very great extent under control. Moreover, we have found that the volumetric determination of bromine by silver was not materially affected, if at all, by the

same causes. We have thus been led to devise a mode of testing the atomic weight of antimony, which, while it has all the advantages of the gravimetric method previously employed, is free from its sources of error.

If the atomic weight of antimony were 122·00, it would require 1·7900 grams of pure silver to precipitate the bromine from a solution of 2·0000 grams of antimony bromide, while if the atomic weight of antimony were 120·00 it would require 1·8000 grams of silver. Now it is easy to estimate volumetrically $\frac{1}{100}$ of this difference with great certainty. We therefore prepared with great care a button of *pure* metallic silver, which we annealed and rolled out to a thin ribbon. We then weighed out from two to four grams of bromide of antimony, prepared by sublimation as described above, and dissolved this salt in an aqueous solution of tartaric acid, which we then transferred to a liter flask and diluted to about 500 cubic centimeters. We next very accurately weighed out a quantity of silver slightly less than that which calculation showed was required for complete precipitation. This silver was dissolved in nitric acid, and the solution having been evaporated to dryness over a water bath, the silver salt was washed into the flask containing the bromide of antimony. As soon as the supernatant liquid had cleared, the small additional amount of a normal silver solution required to produce complete precipitation was run in from a burette, and measured with the usual precautions. We used no extraneous indicator, because it was important not to introduce any possibly new disturbing element into the experiment, and in the titration of bromine with silver the normal and familiar phenomena, which mark the close of the process, furnish a very sharp indication. The details of one of the determinations were as follows:—

The weight of the bromide of antimony used amounted to 2·5032 grams. To precipitate the bromine from the solution of this material 2·2404 grams of silver would be required if Sb = 122·00 and 2·2529 if Sb = 120·00. We weighed out, with as much accuracy as if we were adjusting a weight, the smaller of these two quantities of metallic silver, and after dissolving the pure metal in pure nitric acid, evaporating the solution to dryness and redissolving in water, we added at once the whole of this silver solution to the liter flask containing the solution of bromide of antimony, in the manner described above. It was then found that $12\frac{4}{10}$ cubic centimeters of a normal silver solution (one gram of silver to the liter) were required to complete the precipitation. It will be seen that the weights of the bromide of antimony and silver used could be thus determined with the most absolute precision, and we have the

greatest confidence in these values to the $\frac{1}{10}$ of a milligram. Moreover, it will be noticed that the volumetric method is only used to estimate the difference in the atomic weight which has been in question, and that if the method were only accurate to the $\frac{1}{10}$ of the quantity to be measured it would give us the value of the atomic weight within $\frac{2}{10}$ of a unit; while if, as we had reason to believe, the process was accurate within one per cent, it would fix the atomic weight within $\frac{2}{100}$ of a unit.

By the method just described, the following results were obtained: The letters *a* and *b* indicate different preparations.

Wt. of $SbBr_3$ taken.	Total wt. of Ag used.	Per cent of Br Ag=108 Br=80.	Corresponding value of Sb.
a 1. 2·5032	2·2528	66·6643	120·01
a 2. 2·0567	1·8509	66·6620	120·02
a 3. 2·6512	2·3860	66·6644	120·01
b 4. 3·3053	2·9749	66·6696	119·98
b 5. 2·7495	2·4745	66·6653	120·01
Mean value,		66·6651	120·01
Mean value of fifteen gravimetric determinations previously published,		66·6665	
Theory Sb. 120 requires		66·6666	
" Sb. 122 "		66·2983	

In order still further to control the work, we collected the bromide of silver formed in the last two determinations, washing the precipitate with the precautions which experience had shown to be necessary, and determining its weight, first, after drying at 150° C., and, secondly, after heating to incipient fusion. In *b* 6 there was a loss of $\frac{1}{10}$ of a milligram; in *b* 7 a loss of $\frac{2}{10}$ of a milligram only at the second weighing. This is an absolute proof that there could be no sensible occlusion of any tartaric acid or any tartrate by these precipitates, and, as stated in our original paper, the same test was frequently applied, although not always, in our previous determinations. It is also evident that these last experiments give us two essentially distinct determinations of the atomic weight, although the materials employed were identical with those of *b* 4 and *b* 5.

Wt. of $SbBr_3$ taken.	Wt. of Ag Br determined.	Per cent of Br Ag=108 Br=80.	Corresponding value of Sb.
b 6. 3·3053	5·1782	66·665	120·01
b 7. 2·7495	4·3076	66·667	120·00
Mean value,		66·666	120·00

Lastly, it is obvious that these gravimetric determinations, taken in connection with the corresponding volumetric results, give us the most conclusive evidence of the purity, both of the

metallic silver used, and also of the bromide of antimony, which is the basis of this atomic weight investigation. By comparing *b* 6 and *b* 7 with *b* 4 and *b* 5 respectively, we obtain the following data:—

1. 2·9749 gram of silver gave 5·1782 gram bromide of silver.
2. 2·4745 " " " 4·3076 " " "

Hence it follows that, as shown by these experiments, the proportions of the silver to the bromine were respectively:—

1.	108·00	Silver	to	79·99	Bromine.
2.	108·00	"	"	80·01	"
Mean value,	108·00	"	"	80·00	"

This is the ratio of the atomic weight of silver to that of bromine, and corresponds to the second decimal place with the determinations of Stas as well as with those of Dumas.

In conclusion it gives us pleasure to express our obligations to Mr. G. De N. Hough and Mr. G. M. Hyams, two students of this laboratory, who have greatly aided us in the experimental work of this investigation.

Art. LII.—*Daubrée's Experimental Geology: Part II, Experimental Study of Meteorites with reference to certain Cosmical Phenomena;* noticed by J. Lawrence Smith.

Études Synthétiques de Geologie Expérimentale; par A. Daubrée, Deuxiéme partie—application de la methode expérimentale a l'étude de divers phénomènes cosmologigues.

The first part of Professor Daubrée's valuable work on experimental geology appeared several months since.* The second part, embracing about 350 pages, is exclusively devoted to an experimental study of the structure and genesis of meteoric minerals, and to the bearing of the facts on the constitution of the universe.

The first chapter of the part before us is devoted to the study of the phenomena attending the fall of Aerolites and to their classification. The statement is reaffirmed, "that the two months, August and November, remarkable for showers of shooting stars, have no particular prominence over other months as regards the number of falls of meteoric stones." It is important that this fact should be clearly stated and reiterated, since many scientists are disposed to connect these two classes of phenomena; until shooting stars and meteoric stones are treated of wholly independently, no approach will be made to a correct theory in regard to the origin of the latter.

* This Journal, August, 1879, p. 150.

The composition of meteorites is reviewed, and the well-established fact that but few minerals enter into the constitution of these bodies, however different they may be in physical characters.

The metallic iron, forming either the entire mass or disseminated in small particles through the stones, is invariably a nickeliferous iron, containing a little cobalt and a trace of copper. The stones commonly consist almost entirely of bronzite* or enstatite (sometimes with magnesia as the only protoxide element) and olivine in various proportions, with particles of iron in smaller or greater quantity disseminated through the mass. The next most abundant non-metallic mineral is anorthite, which is found in that class of meteorites called eukrite. Besides these, a few other minerals are more or less constant, but usually in small quantities and some of them in minute proportions, such as troilite, schreibersite, chromite, daubréelite, etc. Other well-known physical and chemical characters are referred to in the same chapter.

The most interesting part of Professor Daubrée's labors relates to the fusion of meteorites and their artificial imitation. In the first class of experiments the results show that the fusion of meteoric stones does not alter materially the character of the minerals contained in them, except that the crystals of the minerals become better characterized, as seen by examination under the microscope.

The fusion of the eukritic meteorites present some remarkable features; "they yield a product wholly different from the other magnesian meteorites, namely: a vitreous mass sometimes striped by a commencement of devitrification, but without crystals of olivine or enstatite." "In the same experiments, a substance is obtained that does not appear to have been seen in the magnesian meteorites; this is titanium (in the state of carbo-azotide) recognized by its characteristic color and by its not being attacked by acids.

The imitation of meteorites by the reduction of terrestrial rocks was successfully made by fusing rocks consisting principally of pyroxene (a mineral closely related to enstatite) and olivine. In operating upon olivine and lherzolite in large quantities, by fusing them in a crucible *brasqué*, buttons of iron were obtained giving regular figures when etched, and containing nickel and cobalt. In another series of experiments, hydrogen instead of carbon was used as the reducing agent on lherzolite and pyroxene, and the decomposition was effected at a low red heat. The oxide of iron was reduced to metallic iron, and the phosphates to phosphides, the products having a close

* The enstatite, also called bronzite, in its chemical character is a magnesian pyroxene.

chemical analogy to what is found in meteorites. A portion of this part of the volume contains a minute description of the San Catharina meteoric iron, which possesses much interest and is worthy of a still more extended study.

In the second chapter, the deep-seated rocks of our globe are compared with meteorites. There is much that is interesting in the statements in regard to olivine and the transformation of serpentine into olivine. In this connection, Professor Daubrée makes some interesting statements with reference to the association of platinum with serpentine. The presence of metallic iron in native platinum is a distinguishing characteristic and would lead us to infer some connection between the rock matrix of platinum and meteorites.

Daubrée's observations and experiments in regard to the cosmic bodies from which meteorites are derived is of considerable interest, embracing as they do the supposable conditions under which the minerals were formed. In regard to what he considers minerals of reduction—as the iron and schreibersite—he is inclined to attribute their reduction to an atmosphere of hygrogen acting on the rocks at a more or less elevated temperature; how high the temperature was it is impossible to decide. He says: "It was without doubt an elevated temperature, because the anhydrous silicates, as olivine and pyroxene, are the products; yet at the moment of solidification and crystallization, the temperature appears to have been inferior to that which I employed in my previous experiments [those of fusing the meteorites]. Two facts would lead us to this conclusion." "The elevated temperature, produced in the laboratory, resulted in the formation of distinct and large crystals, such as are never found in meteorites. It is worthy of note that the siliceous substances which compose ordinary meteorites are always in small confused crystals, notwithstanding the extreme tendency of the minerals to crystallize. Beside this production of small confused crystals, there is a manifest tendency for them to assume a globular form."

The author compares meteorites with the rocks of our globe and brings out the contrast in a striking manner, showing their entire dissimilarity with our sedimentary rocks; and also with granite, gneiss, mica schist and other rocks of this family, whose minerals, as tourmaline and other silicates, are never present in meteorites. It is only below the granites that we encounter rocks at all analogous to meteorites; and in these occur all the elements and many of the minerals that are to be found in them. This, in connection with what the spectroscope has developed, points to a unity in the origin of celestial bodies and in the constitution of the universe, a fact illustrated in various lights by the author.

He observes: "Whatever their origin and orbits, the meteorites that fall on our planet show us one of the great methods of change carried on in the universe, consisting in the distribution of the fragments, derived from the destruction of certain stars, planets or asteroids, among other suns and planets. Such occurrences are not accidental or exceptional phenomena, but facts under a law of the universe. In establishing a close relation between meteorites and the deep-seated rocks of our globe, we not only unravel remote phases in the history of our own globe, but establish the intimate relation that exists between the different parts of the universe." "It is thus that geology, taken in its broadest sense, has an intimate relation to physical astronomy, for if it receives light, it also contributes light."

The second section of this part of Professor Daubrée's work treats of the mechanical phenomena connected with meteorites. Under this head are included the globular structure which characterizes many of the minerals, the polyhedral forms of meteorites, and the pitting on their surface. This last characteristic is treated at great length, and is attributed to sudden heating in connection with great gaseous pressure. Numerous examples are given of experiments on stone, iron and steel with gunpowder and dynamite; and over forty pages of the work are devoted to the details connected with them.

In the application of this part of the subject, Professor Daubrée says: "Those meteorites, which have a fragmentary structure and are very often polyhedral in form, exhibit on their surface the effects of the action of compressed and heated gases, the indentations affording evidence of a wearing action by air in a cyclonic movement." When meteoric masses have been isolated from each other after entering the atmosphere their surface, during their course, has been exposed to compressed and incandescent gases, from the time that they became luminous to that when they have exploded, at which time the incandescence ceases. The track of a meteorite while thus incandescent is often over one hundred and twenty-five miles, and takes several seconds. During this time, it certainly cannot preserve, in the midst of powerful erosive action, its polyhedral form, with well defined angles and edges." These deductions are certainly reasonable. It is evident that the powerfully compressed air is the cause of their frequent explosions attended with rupture of the mass; for the compression of the air may be supposed to reach 1000 atmospheres, and the bolides are turned and twisted in every direction in the midst of this condensed gas.

In the latter part of this work the other peculiar physical characters of meteorites are considered: the black veins, the

marbled structure of the coating of some of them, and also the pulverulent variety of meteorites, or, as it is sometimes called, meteoric dust, etc.

I have thus given a statement of some of the prominent features of this most admirable work on the mineral and geological study of meteorites, embracing not merely descriptions, but also the results of well-directed experiments, and comprehensive philosophical conclusions. We have nothing like it in our scientific literature; and being the result of the labors of so distinguished a geologist as Professor Daubrée, one who has devoted much thought and labor to the subjects of which he treats, it deserves the closest study. The first part of the work I have not referred to, for it has been made known to us briefly in a former notice in this Journal, and quite fully in Professor Dana's recent edition of his Manual of Geology, which work cites many of the facts and conclusions, and some of its excellent illustrations.

In the preparation of both parts of this volume, the publisher has done his part most thoroughly, the paper and typography being such as are rarely equalled in scientific publications, and the illustrations in the text, which are very numerous, being of unusual beauty. The work is one that should find its way to the library of every geologist.

ART. LIII.—*Bastnäsite and Tysonite from Colorado*; by O. D. ALLEN and W. J. COMSTOCK. (Contributions from the Laboratory of the Sheffield Scientific School. No. LX.)

THE material for the investigation, the results of which are here given, was received from Messrs. S. T. Tyson and H. E. Wood, to whom our thanks are due.

The first mineral examined was found by careful qualitative analysis to contain only the metals of the cerium group, fluorine and carbonic acid, with a trace of iron. Its characters are as follows: Hardness=4–4·5. Sp. gr.= 5·18, 5·20. Luster vitreous to resinous. Color reddish brown. Streak light yellowish gray. Infusible. Is very slightly attacked by hydrochloric acid, without perceptible evolution of carbonic acid. Strong sulphuric acid dissolves it with evolution of carbonic and hydrofluoric acids. Strongly heated in a closed tube shows scarcely a trace of moisture. The direct results obtained by analysis are:

	I.	II.	Mean.		Swedish bastnäsite by Nordenskiöld.	
Ce_2O_3	40·88	41·21	41·04	75·80	28·49	74·26
$(La, Di)_2O_3$	34·95	34·56	34·76		45·77	
CO_2	20·09	20·20	20·15		19·50	

By converting a known weight of the mixed oxides of the mineral into anhydrous normal sulphates, the joint atomic weight of the metals was found to be 140·2. If from the carbonic acid obtained, an amount of the bases is calculated sufficient to form normal carbonate, the remainder of the bases calculated as metals and the fluorine estimated by difference, the mean becomes:

		Ratio.
$(Ce, La, Di)_2O_3$	= 50·13	·153
Ce, La, Di	= 21·82	·155
CO_2	= 20·15	·458
Fl	= 7·90	·416
	100·00	

$$R_2O_3 : R : CO_2 : Fl = 1 : 1·01 : 3 : 2·72,$$

corresponding to the formula

$$R_2Fl_6 + 2\,R_2(CO_3)_3$$

in which R=Ce, La and Di. If the atomic weight of R=140·2, as found in the present case, the formula requires:—

$(Ce, La, Di)_2O_3$	= 49·94
Ce, La, Di	= 21·32
CO_2	= 20·07
Fl	= 8·67
	100·00

This mineral corresponds to that from Sweden described by Hisinger* under the name of Basiskfluorcerium. It was later re-investigated by A. E. Nordenskiöld,† who first ascertained its correct composition and called it *hamartite*. Huot had, however, previously called the mineral *bastnäsite*, after the locality. Nordenskiöld's analysis is given above for comparison.

Associated with *bastnäsite* occurs a mineral which proved to be an anhydrous normal fluoride of cerium, lanthanum and didymium, which we have examined with the following results:

H. = 4·5–5. Specific gravity = 6·14, 6·12.

Luster vitreous to resinous. Color pale wax yellow. Streak nearly white. B.B. blackens but does not fuse. In closed tube decrepitates, the color changes to a light pink, and shows slight traces of moisture. Insoluble in hydrochloric and nitric acids, but dissolves in concentrated sulphuric acid with evolution of hydrofluoric acid. Qualitative examination showed only the presence of fluorine and the metals of the cerium group.

Quantitative analysis gave the following results:

	I.	II.	Mean.	Ratio.	
Ce	= 40·16	40·22	40·19	·284‡	·504
La, Di	= 30·29	30·45	30·37	·220§	
Fl (diff.)	= 29·55	29·33	29·44		1·547
	100·00	100·00	100·00		

* Œf. Ak. Stockh., 1838, p. 187. † Œf. Ak. Stockh., 1868, p. 399.

‡ Bürich's atomic weight (141·2) for cerium was used for calculations.

§ A known weight of the mixed oxides was converted into anhydrous normal sulphates, care being taken that the cerium should exist wholly as cerous sul-

From which is obtained the ratio

$$R : Fl = 1 : 3{\cdot}07.$$

The formula $(Ce, La, Di)_2Fl_6$ appears therefore to express the composition of the mineral. As this mineral differs essentially in chemical composition and physical properties from any mineral hitherto described, it should be regarded as a new species. We propose for it the name *Tysonite*.

The process of analysis used for both minerals was as follows: a solution was effected by strong sulphuric acid. After removing the excess of sulphuric acid the sulphates were dissolved in water. The bases were precipitated with ammonium oxalate, the oxalates ignited in air and finally in hydrogen in order to remove the slight amount of oxygen which Di_2O_3 takes upon ignition in air. The cerium in the mixed oxides was determined volumetrically by Bunsen's method. The CO_2 was determined by ignition in a combustion tube with lead chromate mixed with a little fused potassium di-chromate. A trial of this method with pure calcium carbonate mixed with calcium fluoride gave satisfactory results.

Locality and mode of occurrence.—The material first furnished to us by Messrs. Wood and Tyson came from a locality at that time unknown to them, and consisted of a few grams of fragments of crystals of bastnäsite, to some of which were attached portions of the tysonite, readily distinguishable by its lighter color and perceptible cleavage, which is wholly lacking in the bastnäsite. Mr. Tyson, having recently succeeded in reaching the locality, which is near Pike's Peak, has just placed in our hands for examination all the specimens which he could obtain, about a dozen crystals and fragments of crystals, the largest of which are upwards of an inch in diameter, mostly free but in some cases attached to feldspar.

The crystals are hexagonal in form, the only planes observed being O, I and *i*-2. On a single crystal can be seen the remains of pyramidal planes, but so rounded by abrasion that any measurements would be useless. The crystals are prismatic in habit, the smaller ones slender and somewhat elongated, the larger ones short and thick.

These specimens show an interesting relation between the fluoride and the fluo-carbonate. The smaller crystals consist wholly of fluo-carbonate; in the larger crystals, however, a portion occupying the interior, about equally distant from the basal planes, usually about half an inch from them and extending nearly to the lateral planes, consists of the *fluoride*. The thickness of this band varies with the length

phate. The weight of cerium in the oxides used being known (and its state of oxidation), the joint atomic weight of the lanthanum and didymium may be calculated from the mixed sulphates obtained. Two such experiments gave the numbers 137·9 and 138·1, the mean of which (138) was used for calculations.

he crystals from a few lines to half an inch. The line lemarkation between it and the fluo-carbonate is quite inct. This mode of occurrence of the two compounds, ıg such as is often seen in crystals which have undoubtedly ergone partial changes of composition, leads to the conclu- that the bastnäsite of Colorado was formed by a change of ıoride into a fluo-carbonate. In the fluoride a distinct but strongly marked cleavage exists parallel to the basal planes ıe enclosing fluo-carbonate. In the latter we could detect ›vidence of cleavage.

:. LIV.—*On Argento-antimonious Tartrate* (*Silver Emetic*); y JOSIAH P. COOKE. (Contributions from the Chemical aboratory of Harvard College).

.s stated by us in our paper on the atomic weight of anti- ıy,* this compound was originally obtained by Wallquist precipitating nitrate of silver with tartar emetic, and was .yzed both by him and by Dumas and Piria. These chem- obtained respectively 27·31 and 28·05 per cent of oxide of er. They appear however to have prepared the substance r in an amorphous form. As stated in the paper just cited, first noticed the formation of crystals of the compound in a centrated solution of antimonious chloride and tartaric acid, which had been added an excess of argentic nitrate, and n the circumstances of their formation we were led to form mewhat erroneous inference in regard to their relation to er. We find that the substance is far more soluble in this ent than at first appeared. We have found from further estigation that one part of silver emetic dissolves completely ne hundred parts of boiling and in somewhat less than five dred parts of water at 15° C. In one determination made evaporation, a saturated solution, which had stood a long e at a temperature of 15°, we found that 1000 parts of water dissolved 2·76 parts and in another 2·68 parts of the salt. re is obviously therefore no danger of the formation of this luct in the precipitation of chlorine, bromine or iodine from tions of the antimony compounds of these elements in aric acid, unless the excess of silver nitrate is larger and solutions concentrated; and although we have most care- y looked for it in the precipitate we have never discovered xcept under the peculiar conditions described in our former er, and our fear that it might be occluded by these precip- es was wholly unfounded.

: is evident from the above experiments that the solubility

* This Journal, p. 382.

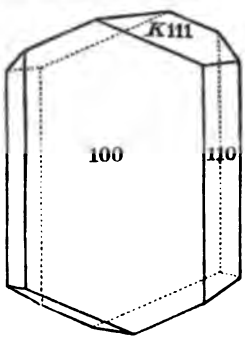
of silver emetic in water like that of cream of tartar and other salts of tartaric acid is very greatly increased by heat, and we were easily able to obtain good crystals of the compound in large quantities by dissolving the precipitate, obtained as Wallquist describes, in boiling water, and allowing the solution to cool. The crystals are colorless and have a very brilliant, almost an adamantine, luster.

From the reaction by which silver emetic is formed we should infer that the composition of the salt would be expressed by the symbol

$$Ag, SbO, H_2 \equiv O_4 \equiv (C_4H_2O_2) \ . \ H_2O.$$

This compound would theoretically contain 26·34 p. c. of silver, and, as a mean of three analyses, we obtained for the amount of silver in the crystals 26·30 per cent, as previously stated.

The crystals of silver emetic rapidly blacken in the light and are very easily decomposed by heat. This decomposition takes place at about 200° C. with a slight explosion. A very fine carbon dust is blown out of the crucible and a residue is left behind, which under the microscope is seen to consist of spangles of metallic silver mixed with an amorphous powder. Almost the whole of the powder dissolved easily in a solution of tartaric acid, and it evidently consisted of Sb_2O_3. In one experiment we weighed the silver emetic and the product, and found that 0·8460 gram. of the salt left 0·5304 gram. of residue. If the residue consisted solely of silver and Sb_2O_3, theory would require 0·5200 grams, and it can be seen from this how perfect the decomposition was. It is obvious therefore that were this compound occluded as we at first feared, it would have made itself evident on drying the precipitates.



Mr. W. H. Melville, assistant in this laboratory, has made the following crystallographic measurements of the crystals whose formation and reactions we have described.

Angles between normals.

$(111) \wedge (100) \quad 70° \ 19\frac{1}{3}'$

$(111) \wedge (\bar{1}11) \quad 70° \ 17'$

$a : b : c = 1 : 1·386 : 0·571$

		I.	Measured.
100	110	54° 12′	54° 19′
111 ∧	110	54° 51′	54° 54′

The pinacoid planes were irregular and the angles can only be regarded as approximate.

System Trimetric with hemihedral habit.

Observed planes + $\varkappa$ | 111 | | 100 | | 110 | | 011 | ?

In the following table the crystallographic ratios are comred with those of the acid tartrates of rubidium, cæsium and tassium, formerly measured by us, and which have the same neral form and hemihedral habit.

	Vertical.	Macro.	Brachy.
Acid tartrate of cæsium	0·661	1	0·694
Acid tartrate of rubidium	0·695	1	0·726
Acid tartrate of potassium	0·737	1	0·711
Silver emetic	0·412	1	0·721

RT. LV.—*The Sternum in Dinosaurian Reptiles;* by Professor O. C. MARSH. (With plate XVIII).

THE presence of a sternum in Dinosaurs has long been in ubt, as hitherto this element has not been found in position, identified with certainty among the known remains of the oup. The evidence in favor of an ossified sternum in these ptiles rests mainly on a single bone, found, in the Jurassic of igland, with the remains of *Ceteosaurus*, and described by illips.* Owen subsequently accepted this determination, d reproduced the original figure of this supposed sternum.† few other specimens have been referred, with doubt, to the rnum of Dinosaurs, but apparently without any particular ison for the reference.

The Yale Museum has recently received a nearly comete skeleton of *Brontosaurus excelsus*, one of the largest iown Dinosaurs. This huge skeleton lay nearly in the posin in which the bones would naturally fall after death, and tunately the entire scapular arch was in excellent preserva-n. The coracoids were in apposition with their respective ipulæ on each side, and between them lay *two* flat bones, at clearly belong to the sternum. This discovery, as interting as it was unexpected, removes the main uncertainty out the scapular arch of Dinosaurs, and likewise indicates a w stage in the development of this structure, not before seen adult animals.

These two sternal bones are suboval in outline, concave ove, and convex below. They are parial, and in position arly or quite joined each other on the median line. The terior end of each bone is considerably thickened, and there a distinct facet for union with the coracoid. The posterior d is thin, and irregular. These bones are shown in position

* Geology of Oxford, p. 268, 1871.

† Palæontographical Society, p. 31, 1875.

on Plate XVIII, figure 1, and one of them is more fully illustrated in figure 2. The inner anterior margin of each bone is smooth and rounded, and gives no evidence of union with an episternal element, which the vacancy there suggests. The amount of cartilage between these two sternal bones, or posterior to them, is not indicated by the present specimens. They were evidently separated by cartilage from the coracoids.

The nearest analogy among living forms to this double sternum may perhaps be found in immature birds. A close resemblance is apparent in the scapular arch of the young American Ostrich, represented on the same plate, figure 3. If the ossification of the sternum were permanently arrested at this stage, it would afford almost precisely the structure seen in the genus *Brontosaurus;* and this is evidently the true explanation of the fossil specimens here figured.

It is more than probable that, in many Dinosaurs, the sternum long remained cartilaginous, or so imperfectly solidified that it is not usually preserved. Several specimens of the genus *Camptonotus*, found nearly in their natural position, were apparently destitute of an ossified sternum. The large size, and doubtless great age, of the specimen of *Brontosaurus* above mentioned may perhaps have been the cause of its more perfectly developed sternum.

Yale College, New Haven, April 11, 1880.

ART. LVI.—*On the Southern Comet of February*, 1880; by B. A. GOULD.

ON the evening of February 2nd, before the twilight was fully past, my attention was drawn to a remarkable streak of light in the southwest, which extended through about 18°, at an angle not much inclined to the vertical. Its lower extremity was perhaps 20° above the horizon, and the brightness was in no part much, if indeed any, greater than that of a star of the 5½ magnitude. It seemed to taper in both directions, fading away at each extremity, and to be between 1° and 2° wide in the middle. A moment's reflection assured me that what I saw must be part of the tail of a comet, the lower portion being obscured by haze and its nucleus being below the horizon, which was concealed by a bank of clouds. No time was lost in preparing for an accurate drawing of its position, but the mist and clouds obscured it completely within a very few minutes, before any delineation could be made. Messrs. W. G. Davis and C. W. Stevens did, however, plot from memory upon the index-map of the Uranometry a sketch of its position and form, which seemed correct to both.

Inquiries the next morning showed that the same phenomenon had been observed on the evening of February 1st, by several persons, and one assured me that he had noticed it on the evening of Saturday, January 31st. All had supposed it to be connected in some way with the burning of grass or bushes, an occurrence which is here so frequent as to attract little attention, but which caused me useless labor and inquiry on more than one occasion during the first year of my residence in this country.

In the evening the ray or streak was about 30° long, and a little brighter than on the previous night, and it had moved laterally northward. Still, a careful search, beginning immediately after sunset, failed to discover the head, or indeed any increase of brightness in the vicinity of the horizon, although the direction of the tail seemed toward the position of the sun. Careful drawings were independently made, on this and each subsequent evening during its visibility, by Mrs. Gould and Mr. C. W. Stevens; the maps Nos. 2 and 3 of the Uranometry affording an excellent means for very minute delineation.

On the 4th I saw the head for a few moments in the twilight. It scarcely seemed brighter than Encke's comet appeared under similar circumstances at its last perihelion; but it was much larger and had a coarse and undefined aspect. No nucleus was visible. There was no opportunity to discover any comparison-star, before it was lost in the mists of the horizon; but a rough position was obtained by means of the setting-circles of the equatorial. This gave, for $5^h\ 27^m\ 55^s$ of Cordoba sidereal time, R.A. $22^h\ 24^m\ 10^s$, Decl. $-31°\ 29'{\cdot}1$. The altitude of the comet having been less than $2°\ 42'$, no great reliance can be placed on this determination, which was moreover crude in other respects.

On February 5th, I obtained tolerably good comparisons with an undetermined star, the approximate position of which is $22^h\ 41^m\ 40^s$, $-32°\ 27'$ for the mean equinox of 1880·0; and from that date to February 19th, there were but two evenings on which observations were not secured, the sky having been especially propitious during that period. The tail, which I think was brightest February 6th or 7th, although then not more brilliant than the Milky Way in Taurus, maintained its inordinate length of from 35° to 40° until it faded from view, which took place only five days before the head became invisible in the 11½ inch equatorial. Indeed it was with the greatest difficulty that I was able to observe it on the 19th, when it was only to be recognized as a slight whiteness in the field, unnoticeable without special attention. No nucleus was visible at any time during the whole duration of its visibility, nor was there any definite form or even perceptible outline to

the head, excepting on one or two nights at the beginning of the series of observations. It then exhibited an elongated form, somewhat rounded at its anterior margin, and shading away to form the tail, which was but little inferior in brightness, and seemed lost from view in the telescope in consequence of its lateral expansion almost as much as by any defect of its total light. On the 20th, the comet could not be detected in the telescope, although my ephemeris was so accurate as to leave no doubt concerning its position in the field.

The positions of the comparison-stars employed on the 7th, 8th and 11th cannot be sharply determined for several months. The observations on other days give the following results which are uncorrected for parallax, or aberration.

	Cordoba M. T.	R.A.	Decl.
	h m s	h m s	° ′ ″
1880, Feb. 6,	8 37 56·3	22 58 32·9	−32 55 55·0
9,	8 47 37·8	23 50 51·4	33 45 41·7
12,	8 23 40·8	0 39 51·0	33 6 15·3
14,	8 24 49·3	1 9 21·8	32 2 48·0
15,	8 27 38·9	1 22 58·1	31 23 19·1
17,	8 37 51·8	1 47 43·9	29 54 32·5
18,	8 34 4·5	1 58 55·2	29 7 12·8
19,	9 0 26·8	2 9 34·4	−28 17 44·8

The excessive length of the narrow tail, its lack of gradation in brilliancy, and the relative faintness of the head, formed very notable characteristics. But, to my astonishment, on computing a parabola from the observations of February 6th, 9th and 12th, I found reproduced the orbit of the Great Comet of 1843. The almost incredibly small perihelion distance suggests in each case the origin of the huge tail; but the other elements were almost equally similar. A second orbit, from observations embracing the twelve days' interval from February 6th to 18th, proved equally similar to the orbit resulting from Hubbard's unsurpassed discussion of the Comet of 1843; and leaves no doubt whatever in my mind as to the identity of the two bodies, notwithstanding that an ellipse of 532 years was found to afford the best representation of the series of observations in 1843 as a whole. The elements now obtained are these: which are expressed in Washington mean time, and referred to the mean equinox of 1880·0.

T	1880, Jan. 27^d·40479
☊	6° 10′ 29″·6
ω	86° 18′ 19″·0
i	144° 39′ 38″·8
log q	7·7393644

This result leads, however, to a yet more remarkable inference. At the time of apparition of the Comet of 1843, its identity with that of 1668 was very generally discussed and credited. Only the circumstance that Hubbard found the total

series of observations to be more satisfactorily represented by an ellipse of much longer period served to weaken this belief to any extent. Nevertheless Hubbard showed that the corresponding diminution of the major axis was compatible with a probable error of only $\pm 11''\cdot 32$ for a single observation, in place of $\pm 8''\cdot 44$ to which this value would be reduced by the adoption of his final elements. The similarity of the comet's appearance to that of 1702 also attracted attention. The orbit calculated for that comet by Struyck in Amsterdam bears no similarity to the well-determined one of the comet of 1668; but Cassini, who observed the former, believed the two to be identical. The same opinion was maintained by Cooper in 1843. The tail in 1702 was 40° long, and its path was chiefly in the southern hemisphere, both which facts favor the supposition of identity. Nevertheless, while a computation by Petersen, using for 1702 the orbit of the Comet of 1843, showed that the roughly given geocentric path might thus be somewhat roughly represented, Schumacher considered that the resultant places were compatible neither with the position of the tail March 2, 1702, as described by Maraldi, nor with the observation of the ship-captain Brouwer, cited by Struyck.

The interval between the perihelion-passages of 1668 and 1702 differs from 34 years by only a few days; that between those of 1843 and 1880 is but a month less than 37 years. If these three apparitions belong, as I am convinced, to one and the same comet, we have the singular phenomenon of a rapidly increasing period, for the interval from the perihelion of 1702 to that of 1843 is just 141 years, which gives 35¼ years for the average length of the four intermediate periods. The assumptions that the increase of the period has been systematic and that no other important perturbations have affected the times of perihelion-passage give for the successive returns to perihelion the following dates:—

1702 Feb. 23.	1771 June 6.	1843 Feb. 27.
1736 July 12.	1806 Dec. 12.	1880 Jan. 27.

The second Comet of 1806 appears to have passed its perihelion on December 28th of that year. The latest determination of its orbit is that by Hensel in 1862, the resulting inclination being essentially the same as that of the present comet. His other elements, however, are completely discordant, the form of the orbit being hyperbolic and the perihelion-distance large. It remains to be seen whether the observations could be represented by an orbit of different form and dimensions. There are other recorded apparitions which seem likely to have been returns of the same comet, such as those of the years 1533, 1468, and perhaps 1264; but I have not here the means of forming any careful opinion.

It might perhaps be supposed that no appearance of so impressive an object during the last two or three centuries could have failed to be recorded; but it does not seem so to me in the case of a comet whose orbit lies almost exclusively to the south of the ecliptic, so that it would in all probability be noticed in our northern hemisphere only in the northern winter.

The wonderfully small, and apparently diminishing perihelion-distance affords an explanation of the increasing period; for, according to the present elements, this distance is but 0·00549, while the sun's own radius is 0·00466. It seems impossible that one side of the coma should not suffer actual friction against the body of the sun, to say nothing of its traversing the densest portion of his atmosphere through a full semi-circumference. The mechanical resistance thus interposed must have acted to diminish the perihelion-distance; and we find this accordingly to have been 0·005538 after the passage of 1843, and 0·005487 after that of 1880. Yet, while this resistance and the lateral friction must during their continuance be causing a diminution of the radius-vector, it would appear that they have not diminished, but, on the contrary, increased, the major axis. This is a delicate and in some respects a difficult question; and since I have at present neither the requisite time nor books of reference at my disposal, I will not here enter into any of its details, but will confine myself to the statement that so far as I am able to form an opinion, the observed facts do not appear to conflict with theory.

A most interesting question arises regarding the densest portion of the tail. There is no reason to doubt that this pointed southward before the perihelion, as it did afterward. Now the comet's center of gravity passed from one side to the other of the sun, describing an arc of 180° in true anomaly in about $2^h\ 8^m$; and indeed described 141° 42′ in a single hour. If the tail in general consisted of the same particles before as after the hour of perihelion, it must have been actually severed by the body of the sun, surrendering of course a considerable amount of its material.

In conclusion, I append the dimensions and position of the tail for each night of its visibility, given by means of the declinations of the intersection of its axis with the principal meridians upon the chart, and the width at these points of intersection. They are derived from the drawings of Mr. Stevens, and confirmed by the absolutely independent and accordant ones of Mrs. Gould. The positions of the head are as measured from these drawings, made upon map 2 of the Uranometria Argentina, without any reference to the ephemeris; but the ephemeris from the elements already given accompanies them.

The observed length of the tail depended, to a considerable degree, upon the clearness of the night.

Ephemeris for Washington mean Noon and mean Equinox 1880·0.

1880.	R. A. h m s	Decl. S. ° ′ ″	log Δ.	log r.
Feb. 2	21 47 33	28 57 27	9·868303	9·533186
4	22 19 9	31 10 55	9·847750	9·622916
6	22 52 59	32 45 2	9·835007	9·691392
8	23 27 52	33 36 1	9·829783	9·746770
10	0 2 18	33 43 58	9·831555	9·793264
12	0 35 0	33 13 55	9·839451	9·833330
14	1 4 59	32 14 12	9·852389	9·868533
16	1 31 48	30 54 13	9·869191	9·899922
18	1 55 27	29 22 31	9·888754	9·928246
20	2 16 6	27 45 47	9·910133	9·954049
22	2 34 8	26 8 41	9·932570	9·977744
24	2 49 53	24 34 13	9·955492	9·999648
26	3 3 42	23 4 7	9·978483	0·020014
28	3 15 56	21 39 14	0·001251	0·039043

Positions as measured from the drawings.

Date 1880.		Feb. 2.	Feb. 3.	Feb. 4.	Feb. 5.	Feb. 6.	Feb. 7.
Cordoba M. T.		8^h20^m	8^h20^m	8^h35^m	8^h30^m	8^h35^m	8^h35^m
Head	R. A.			22^h24^m	22^h40^m	22^h59^m	23^h17^m
	S. Decl.			31°20′	32° 0′	32°50′	33°25′
End	R. A.	23^h36^m	0^h40^m	1^h16^m	1^h50^m	2^h20^m	2^h32^m
	S. Decl.	57° 0′	60° 0′	57°40′	55°40′	52°40′	49°30′
Length seen		18°	30°	40½°	42¼°	41½°	40¾°
At 22^h40^m	S. Decl.	43°45′	38°20′	35° 0′	32°45′		
	Width	1°40′	1° 0′	0°30′	0°15′		
At 23^h0^m	S. Decl.	39°30′	42°40′	38°45′	35°43′	33°20′	
	Width	1°45′	1°40′	1°20′	0°45′	0°15′	
At 23^h20^m	S. Decl.	54°10′	46°50′	41°48′	38°45′	36°40′	34°20′
	Width	1°40′	1°40′	1°40′	1°38′	0°50′	0°15′
At 23^h40^m	S. Decl.		50°50′	45°50′	41°45′	39°17′	36°25′
	Width		1°40′	2° 0′	1°42′	1°35′	0°50′
At 0^h0^m	S. Decl.		54°25′	49°10′	44°35′	41°15′	38°50′
	Width		1°40′	2° 0′	1°50′	1°40′	1°35′
At 0^h20^m	S. Decl.		56°55′	51°55′	46°55′	43°35′	40°52′
	Width		2° 0′	2° 0′	2° 0′	1°50′	1°40′
At 0^h40^m	S. Decl.		60° 0′	54°20′	49°30′	45° 3′	42°30′
	Width		2° 0′	2° 0′	2° 0′	2° 0′	1°50′
At 1^h0^m	S. Decl.			56°35′	51°35′	46°55′	44°10′
	Width			2° 0′	2° 5′	2° 0′	1°50′
At 1^h20^m	S. Decl.				53°20′	48°45′	45°38′
	Width				2°10′	2°10′	1°50′
At 1^h40^m	S. Decl.				55° 0′	50° 3′	46°55′
	Width				2°10′	2°10′	2° 0′
At 2^h0^m	S. Decl.					51°50′	48° 5′
	Width					2°10′	2° 0′
At 2^h20^m	S. Decl.					52°40′	49°10′
	Width					2° 0′	1°50′

	Date 1880.	Feb. 8.	Feb. 9.	Feb. 11.	Feb. 12.	Feb. 14.
	Cordoba M. T.	8^h40^m	8^h50^m	8^h25^m	8^h35^m	8^h50^m
	Head R. A.	23^h32^m	23^h43^m	0^h23^m	0^h40^m	$1^h\ 7^m$
	S. Decl.	33°41′	33°50′	33°45′	33° 5′	32° 6′
	End R. A.	2^h45^m	2^h53^m	3^h12^m	3^h32^m	3^h50^m
	S. Decl.	47°25′	45° 0′	40°50′	38°35′	36° 0′
Length seen		39½°	39½°	35°	34½°	34°
At 23^h40^m	S. Decl.	34°40′				
	Width	0°15′				
At 0^h0^m	S. Decl.	36°50′	35° 2′			
	Width	0°40′	0°15′			
At 0^h20^m	S. Decl.	38°45′	36°42′			
	Width	0°45′	0°25′			
At 0^h40^m	S. Decl.	40° 3′	38° 0′	35° 2′	33° 5′	
	Width	0°50′	0°40′	0°12′	0° 0′	
At 1^h0^m	S. Decl.	42° 0′	39°40′	36°55′	34°25′	
	Width	1° 5′	0°50′	0°10′	0°10′	
At 1^h20^m	S. Decl.	43°20′	40°30′	37°40′	35°25′	32°35′
	Width	1°30′	1°10′	0°20′	0°15′	0° 5′
At 1^h40^m	S. Decl.	44°35′	41°35′	38°35′	36°20′	33°20′
	Width	1°50′	1°20′	0°35′	0°13′	0° 5′
At 2^h0^m	S. Decl.	45°25′	42°30′	39°15′	37°25′	34°10′
	Width	1°50′	1°40′	0°40′	0°20′	0°10′
At 2^h20^m	S. Decl.	46°10′	43°50′	40°10′	37°50′	34°35′
	Width	1°40′	1°40′	0°50′	0°15′	0°15′
At 2^h40^m	S. Decl.	47° 0′	44°15′	40°25′	38°10′	35° 0′
	Width	1°30′	1°25′	0°40′	0°15′	0°10′
At 3^h0^m	S. Decl.			40°20′	38°25′	35°20′
	Width			0°30′	0°10′	0° 5′
At 3^h20^m	S. Decl.				38°45′	35°40′
	Width				0°10′	—
At 3^h40^m	S. Decl.					36°10′
	Width					—

Cordoba, March 3, 1880.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Formation of Ozone by the Slow oxidation of Phosphorus.*—Some doubts having been expressed as to the actual production of ozone by the slow oxidation of phosphorus, McLeod has made a series of qualitative experiments to ascertain whether it is so produced or whether hydroxyl is the product. Oxygen ozonized by the spark in a Siemens tube was passed through a U tube containing solutions of sodium carbonate, of potassium dichromate and sulphuric acid, and of potassium permanganate. The ozone passed readily through these tubes even when surrounded by boiling water. Hydroxyl, on the other hand, is readily decomposed by sodium carbonate, especially at 100°, transforms chromic into perchromic acid and evolves

oxygen with permanganate. The air in which phosphorus was slowly oxidizing was then passed through the same U tube, and then into a solution of potassium iodide and starch. This solution became blue in all cases, when the U tube was cold as when it was heated to 100°. The addition of a second tube containing pumice saturated with sodium carbonate did not alter the result. To test the effect of heat, an apparatus was used consisting of a large U tube containing pumice and sulphuric acid, a narrow U tube, which could be placed in a test tube, a weighed tube containing pumice and sulphuric acid and a flask with potassium iodide and starch solution, acidified. From one to five liters of gas were drawn through the tubes very slowly, the narrow tube being cold, plunged in boiling water or in a paraffin bath at 150° to 200°. The second U tube was weighed after each experiment, and the starch solution was decolorized by a deci-normal solution of sodium thiosulphate. The maximum increase in weight in twenty-four experiments was ·0035 gram, in an experiment at ordinary temperatures, the decolorization requiring 3·65 c.c. of the thiosulphate. At 200° the sulphuric acid increased in weight ·0006 gram, the decolorizing solution used being 1·8 c.c. Since one c.c. of this solution corresponds to ·017 gram hydroxyl, which would yield on decomposition by heat ·009 gram water, and at 200° at least half the hydroxyl would be destroyed, an increase of ·016 gram instead of ·0006 gram might have been expected had hydroxyl been present. Moreover, contact with strong sulphuric acid did not render the gas inactive. Hence the author's conclusion that the gas formed during the slow oxidation of phosphorus is actually ozone.—*J. Chem. Soc.*, xxxvii, 118, Feb., 1880.

G. F. B.

2. *Explosion of a Platinum Alembic used for concentrating Sulphuric acid.*—Kuhlmann (fils) has communicated to the Chemical Society of Paris the particulars of the explosion of a platinum still used in his factory at Lille, for concentrating sulphuric acid. The still was 90 centimeters in diameter, and could concentrate 6 to 7000 kilograms of acid in twenty-four hours. The explosion scattered the fragments of it to a distance of twenty or thirty meters, tearing both the body and the head of the still in pieces, and throwing the bricks of the furnace violently about. Happily a slight hissing one or two seconds before, gave warning to the workmen who left the vicinity and escaped a terrible fate. The cause of the explosion seems to be as follows: The acid had nearly all been withdrawn from the still, a layer five centimeters deep, thirty or forty kilograms, being left in the bottom. Upon this water had been run by means of the syphon, and the whole had been heated slowly for several hours in order to clean the apparatus. It would appear that the acid and water did not combine at once, but that union took place subsequently at an elevated temperature and very rapidly, giving rise to a large production of heat. According to data given by Favre and Silbermann and others, one kilogram of acid added to a suitable

quantity of water, evolves 148 calories. Consequently the forty kilograms of acid would have evolved heat enough to give rise to an instantaneous production of eighteen or twenty cubic meters of vapor; a quantity quite sufficient to burst a platinum vessel of 300 liters capacity whose walls were only two or three millimeters thick. The experiment had been repeated by the author several times, using glass vessels. The explosion always took place with violence provided the water was at least ten molecules for each one of the acid. Pfaundler, using a considerable quantity of the materials, in the ratio of one molecule of acid and 120 of water, has obtained an evolution of 181 calories. The experiments were made, however, at 18°, and the author is examining the production of heat when the mixture takes place at higher temperatures.—*Bull. Soc. Ch.*, II, xxxiii, 50, Jan. 1880. G. F. B.

3. *On the Equivalence of Boron.*—In an investigation of the phenyl derivatives of the nitrogen series, Michaelis had shown that the free equivalence of a chloride appears distinctly if a phenyl group replaces chlorine. Thus phosphorous chloride, which unites difficultly with bromine, combines easily if an atom of phenyl replaces one of chlorine. So monophenylarsenous chloride takes up chlorine readily, while arsenous chloride does not combine with it. In connection with BECKER, MICHAELIS has now studied monophenyl-boron chloride, hoping to obtain the same result, and to obtain a chloride in which boron is a pentad. By the action of boron chloride upon mercury-diphenyl, in sealed tubes at a temperature of 180° to 200°, monophenylboron chloride is obtained as a colorless liquid, easily becoming reddish, boiling at 175°, and solidifying at 0°. When this is placed in a freezing mixture and chlorine passed over it, it is absorbed and the mass liquefies. In the experiment the increase of weight was noted; and it was found that 3·9 grams had absorbed 1·3 grams of chlorine, theory requiring for the two atoms of chlorine absorbed, 1·7 grams. The authors think that these results render probable the existence of a phenyl-boron tetrachloride $C_6H_5BCl_4$ which breaks up easily into boron chloride and monochlorbenzene. Conceding this, boron is quinquivalent.—*Ber. Berl. Chem. Ges.*, xiii, 58, Jan., 1880. G. F. B.

4. *On the Direct Union of Cyanogen and Hydrogen.*—BERTHELOT has succeeded in causing cyanogen to unite directly with hydrogen under the influence of heat. The pure and dry gases, mixed in equal volumes and passed slowly through a narrow tube heated to 500°—550°, combined to an extent of two or three per cent. But if the action be prolonged, the mixture being contained in a sealed tube and heated to the above temperature for several hours, the two combine in equal volumes forming hydrogen cyanide free from cyanogen, only one-seventh of which is transformed into paracyanogen. The phenomenon differs from the synthesis of hydrogen chloride only in its greater slowness and the more elevated temperature required, which is that at which hydrogen unites directly with oxygen, with ethylene, etc.

If the temperature be lower, there is an excess of uncombined hydrogen; if it be very high, free nitrogen is produced. The hydrogen cyanide formed, however, remains intact. Experiments were then made with the metals, and it was found that cyanogen unites directly with them. At 300° zinc, cadmium and iron form cyanides of these metals. Zinc is attacked even in the cold after several days; at 100° in three or four hours. Copper and lead yield a trace of cyanide at 500° to 550°. Silver and mercury do not combine directly with cyanogen at any temperature; probably because the temperature of the reaction is also the temperature of decomposition.—*Bull. Soc. Ch.*, II, xxxiii, 2, Jan., 1880. G. F. B.

5. *On Cellulose and its Nitro derivatives.*—EDER has made an extended examination of the nitro-derivatives of cellulose with a view to determine whether they are compound ethers of nitric acid or are nitro-substitution products. He gives the following reasons for the former view: (1) Alkalies withdraw variable quantities of nitryl forming nitrates; (2) Sulphuric acid even in the cold, expels all the nitryl in the form of nitric acid, a sulpho-ether resulting; (3) Toward ferrous sulphate and chloride, these derivatives act in the same way as nitrates; (4) By treating them with sulphuric acid over mercury, they act like nitrates, all the nitrogen being evolved as nitrogen dioxide; (5) Reducing agents as potassium sulphydrate, sodium stannite, ferrous acetate, etc., convert them into ordinary cellulose. Hence the pyroxylins are nitrates of cellulose and have the general formula $C_{12}H_{20-n}O_{10-n}(O.NO_2)_n$, the formula of cellulose being $C_{12}H_{20}O_{10}$. The author has also examined the definite compounds formed by the action of nitric acid on cellulose. When the perfectly dry cotton is placed in a cooled mixture of three volumes pure concentrated sulphuric acid (1·845) and one volume nitric acid (1·5) for twenty-four hours, and after washing and drying, is treated with a mixture of three parts of ether and one part of alcohol until everything soluble is removed, there is left a compound having the composition of cellulose hexanitrate, and yielding about 14 per cent of nitrogen. By using less concentrated acids, definite compounds were obtained containing less nitryl; the pentanitrate giving 12·57 per cent nitrogen, the tetranitrate with 11·41, the trinitrate with 10·12 per cent (evidently containing tetranitrate) and the dinitrate with 6·89 per cent. All these are soluble in a mixture of ether and alcohol except the first given, the hexanitrate. The mononitrate was not obtained.—*Ber. Berl. Chem. Ges.*, xiii, 169, Feb. 1880. G. F. B.

6. *On a new kind of Ammonium Bases.*—GRIESS has described a new series of ammonium bases obtained by acting on the isomeric amidophenols with excess of methyl iodide. When to a cold solution of one part orthoamidophenol hydrochlorate in methyl alcohol, three parts of methyl iodide is added and then concentrated potash solution to strong alkaline reaction, and the whole is allowed to stand, an acid reaction appears after some

time. This is made alkaline again, and the operation is repeated as long as the solution becomes acid. On distilling off the methyl alcohol, the liquid solidifies to a mass of yellowish colored crystals of orthotrimethylphenolammonium hydriodate. The base is obtained from this by treatment with silver oxide, in well formed prisms, having the formula $C_9H_{13}NO$, or $C_6H_4<\genfrac{}{}{0pt}{}{O}{N(CH_3)_3}$. Several salts of this new ammonium are described, beside the platinum double salt. By treating paraamidophenol in the same way, paratrimethylphenolammonium results.—*Ber. Berl. Chem. Ges.*, xiii, 246, Feb., 1880. G. F. B.

7. *Photographs of Spectra.*—H. W. Vogel has photographed the spectra of oxygen, hydrogen and quicksilver, by means of the sensitive gelatine bromide of silver plates, introduced by Wratten and Wainright, which Vogel regards as fifteen times more sensitive than the most sensitive wet plates. With an exposure of two hours a spectrum from the green to the violet could be obtained by ordinary induction sparks, without the use of a Leyden jar. Full tables of wave-lengths of the lines, with descriptions of their character and list of their coincidences with solar lines, according to different authorities, are given. Vogel confirms the result previously obtained by Wiedemann, that if quicksilver and nitrogen are heated together in a Geissler tube the lines of nitrogen disappear when the tension of the quicksilver increases to a notable extent. From the fact that the Hδ line appears in the Geissler tube at a pressure of 2^{mm} when single induction sparks are discharged through it, Vogel concludes that their existence is not due alone to very high temperatures, as Lockyer assumes. It was noteworthy that in the spectra in tubes the strong mercury line $\lambda=4046$ was entirely absent, while weak lines were present which were not seen with the employment of strong pressure and strong discharges: also by rarefaction and the consequent lowering of temperature, one of the brightest, and, according to Lockyer, longest lines disappears, while many weaker and less refrangible lines remain. Further, not all the lines increase in brightness, but many disappear. The assertion of Lockyer, that with diminishing pressure the shortest lines disappear first, is therefore not true in general.—*Ber. d. Berl. Ak.*, 1879, p. 586. J. T.

8. *The limits of the Ultra Violet in the Solar Spectrum at different heights.*—Cornu has made some spectroscopic tests on the Riffel, at Visp and on the Rigi, and finds results in accordance with those of previous observers. The ultra violet limit is very slightly increased with the altitude of observation. The change of wave-length is about a millionth of a millimeter for 700 meters. The limit at the Riffel was reached at a wave-length of 293·2, and at Visp at 295·4.—*Comptes Rendus*, lxxxix, p. 808, 1879. J. T.

9. *Atmospheric Polarization and the influence of Terrestrial Magnetism upon the Atmosphere.*—The apparatus of Becquerel consisted essentially of a Savart polariscope mounted upon a divi-

ded circle. This divided circle is supported by a horizontal axis which is also capable of turning about a vertical axis. Two other divided circles measure the motion in azimuth and in declination, and allow the polariscope to be directed in any direction, and give also the coördinates of the point of observation. The method of observation was to obtain upon the same divided circle the position of the plane of polarization of the sun and the trace of the plane of the sun. An ingenious method of accomplishing this is detailed in the author's memoir. The conclusions reached are as follows:

(1) The existence at one point of a variable angle between the plane of the sun and the plane of polarization of the atmosphere.

(2) A periodical variation in this angle, which has a maximum and minimum during the day. This phenomenon appears to be connected with the variable conditions of illumination of the atmosphere due to the height of the sun.

(3) The manifestation of the magnetic influence of the earth upon the atmosphere, to which influence can be attributed a small deviation of the plane of polarization of the light.—*Annales de Chemie et de Physique*, Jan., 1880, p. 90. J. T.

10. *Measurements and law in Electro-Optics.*—Dr. KERR continues his experiments upon the effect of electric tension on the transmission of light through dielectrics, and enunciates this general law:—"*The intensity of electro-optic action of a given dielectric, (or the difference of retardations of the ordinary and extra-ordinary rays) per unit of thickness of the dielectric, varies directly as the square of the resultant electric force.*" The dielectric used by Dr. Kerr was carbon disulphide, and was contained in a cell of peculiar construction, which allowed the layer of the dielectric to be submitted to powerful electric stress. A beam of light was passed through a Nicol prism and then through the layer, and was examined by a second Nicol. In subsequent experiments, Jamin's compensator was also used between the layer and the ocular Nicol. Thomson's long-range electrometer was employed to measure the electrostatic effects. The author concludes that Faraday's and Clerk-Maxwell's views in relation to the action of a dielectric in the transmission of electrostatic force, and the state of molecular constraint that is associated with and is essential to that action, are very strongly confirmed by the new facts of electro-optics. "The dioptric action of an electrically charged medium is closely related to the electric stress of the medium, the axis of double refraction coinciding in every case with the line of electric tension, and the double refraction varying, certainly in CS_2 and probably in all other dielectrics, directly and simply as the intensity of the tension."—*Phil. Mag.*, March, 1880, p. 157. J. T.

11. *Connection between the laws of diffusion and Thermodynamics.*—BOLTZMANN, in a valuable paper, discusses the phenomena of diffusion from the point of view of the mechanical theory of heat, and arrives at certain equations expressing the entropy. The equivalent transformation of work due to diffusion, and the maximum work which can be produced by the diffusion of gases at constant temperature.—*Wien. Ber.*, 78, 1878. J. T.

12. *Density of the Halogens at very high temperatures.*—Professor CRAFTS has repeated the experiments of the Messrs. Meyer, with certain modifications, and finds with them that the density of iodine vapor at the temperature obtained with the gas furnace of Perrot is two-thirds of the normal density, although he thinks their estimates of the temperature too high. In experimenting, however, with free chlorine he obtained values corresponding to the normal density of Cl_2.

More recently Victor Meyer has published additional experiments on the same subject, which indicate that while chlorine does not assume the abnormal condition corresponding to $\frac{2}{3}Cl_2$ below 1200 degrees, iodine vapor passes into a similar state at 1000 degrees. He confirms also the results of Crafts in regard to the density of chlorine gas, which had been previously prepared and introduced as gas into the heated flask, finding that under these circumstances the density corresponded approximately to Cl_2 at the same temperature at which the chlorine formed in the flask from $PtCl_4$ assumed the lower density corresponding to $\frac{2}{3}Cl_2$. The old term *nascent* is applied to chlorine in the last condition, and it is suggested that the difference between chlorine gas in these two states of density corresponds to the difference between oxygen gas and ozone at the ordinary temperature of the air. Victor Meyer has further determined the vapor density of bromine under the same condition as chlorine and iodine. He finds that $PtBr_4$ can be easily prepared, and that the bromine vapor formed by its decomposition "in statu nascenti" assumes at the high temperatures employed in these experiments the value 3·64, corresponding to $\frac{2}{3}Br_2$. Experiments to determine the density of free bromine vapor formed by dropping liquid bromine into the heated flask did not give accordant or satisfactory results. Meyer has met with similar irregularities in his experiments on the vapor density of water and other volatile liquids at a white heat, which he attributes to a mechanical cause, depending on the very sudden conversion of the liquid into vapor, which at such high temperatures takes place with explosive violence. Meyer hopes to overcome the difficulties presented in such cases, by using larger vessels, and the several articles published in the Berichte of the German Chemical Society for March 8th, pp. 391 to 408, are obviously only preliminary notices of an investigation still in progress. The idea that a chemical decomposition or dissociation has taken place in these experiments appears to be no longer entertained, and the anomalous densities observed, so far as they are real phenomena, are probably the result of allotropic modifications of the elementary substance similar to those already well known. J. P. C.

13. *Use of the Heliotrope for telegraphic purposes in triangulation.* Letter to J. D. Dana, from Capt. C. P. PATTERSON, Superintendent of the Coast Survey, dated Washington, Mar. 26, 1880. —Having noticed in *Nature* several references to the use of the sun for telegraphic purposes, I beg to say that the heliotrope—a

mirror with directive mounting—has been one of our regular field instruments in triangulation for forty years, and has been used on lines from 20 to 192 miles in length.

As a matter of interest, I send you the following extract from the annual report of Assistant George Davidson, in charge of the most important portion of the triangulation on the Pacific Coast. The stations named are along the western crest of the Sierra Nevada Mountains, along the crest of the immediate Coast Range, and Mt. Shasta, at the head of the Sacramento Valley.

I notice that M. Perrier, in charge of the triangulation in Algeria, in making his connections with Spain, failed—on account of the state of the atmosphere I presume—to obtain satisfactory results from the heliotrope (the distance being as nearly as can be learned 165 miles), and was obliged to have recourse to electric lights, requiring engines of 6-horse power. With these his success was perfect.

[EXTRACT.]—*Heliotrope Spectra.*

My former experience of the decomposition of the heliotrope image of the sun after passing through many miles of the atmosphere was fully verified. The heliotrope images were seldom decomposed on the lines under seventy miles in length, but they were, as a rule, decomposed on all longer lines, and ranged through the formulæ

Blue	Blue	Green	Green
White	Yellow	Yellow	Orange,
Red	Red	Red	Red

the last being the less frequently seen. The peculiar sparkling characteristic of the bright heliotrope image does not announce itself in the spectrum image; the colors give a steady, soft image, which is generally slightly higher than broad; frequently twice as high as broad; and upon some occasions it reaches a height of 60 seconds with a breadth of 10″ to 15″.

In nearly all cases the red is the most marked and is certainly the most persistent; the blue will fade away, the yellow or orange is not in sufficient contrast with the white field to be observed upon. The color of the red is that of the spectrum at the B line. Frequently the red will exist with a sharply defined nucleus of light orange, or even white; but it is doubtful if this exists when the spectrum is formed.

The column of spectrum light sometimes undergoes the most unceasing apparent interchange of the colors, as if the rapid changes in vertical refraction suddenly shortened and lengthened the column; and yet tests failed to show that any part of the column was not in the vertical.

It is only upon rare occasions that the spectrum is seen inverted, and then seldom during the single minute of pointing; but at Mount Lola and at Round Top Mountain the records show where the heliotrope, seen as a diffused disc, had the red and blue at different parts and in different proportions of the circumference with yellowish center. Upon the great lines the spectrum was occasion-

Green
ally very brilliant in Orange, and then it was possible to predict
Red
its visibility to the unassisted eye.

From Mount Lola we have frequently seen the heliotrope images with the naked eye over the longest lines; and at Round Top Mountain, with lines reaching 160 miles, we saw the Snow Mount heliotrope very plainly with the naked eye upon several occasions. I am satisfied that the Mount Helena heliotrope would have been seen with the naked eye from Mount Shasta, 192 miles, in favorable weather. Although the spectrum on such occasions is very vivid, the naked eye did not detect the colors.

In a former paper I have referred to this phenomenon as a normal condition of the heliotrope image, but particularly exhibited in long lines. On short lines the difference of density of the stratum of air traversed by the ray of light is too small to decompose the white light; but on long lines the strata of different densities through which the line passes act practically as a prism by which the ray of white light is decomposed by the different refractive powers into the spectrum.

Heliotropes.—The heliotropes I use are of the pattern which I devised in 1851, except that now a square mirror is adopted as affording more light for the same sized box for transportation. It could be made a parallelogram, but would be less steady in a heavy wind. The larger ones have a screen attached to a lever for transmitting Morse telegraph letters as heretofore.

The ordinary amalgam-backed mirrors become whitish and opaque in a few days' exposure, but the fine silver deposit on the glass retains its brilliancy unimpaired.

I have established the following sizes for heliotropes, and have practically tested them up to 192 miles. I feel certain that the proportions may be carried to any practicable line on the earth's surface.

Dist'ce. Miles.	Surface. Sq. inches.	Side. Inches.	Actually used.	Dist'ce. Miles.	Surface. Sq. inches.	Side. Inches.	Actually used.
10	0·21	0·46	—	130	35·5	6·0	
13	0·36	0·60	0·4	138	40·	6·3	5·6 too weak.
20	0·84	0·92	—	141	42·	6·5	6· weak.
30	1·89	1·37	—	148	46·	6·8	7·
40	3·36	1·83	1·5				6· v. weak.
50	5·25	2·3	3·0 too bright.	160	54·	7·3	8·
60	7·55	2·8	3.0	169	60·	7.7	8·
70	10·28	3·2	3·0	192	77·3	8·8	8· 12· Small telescope.
80	13·4	3·7	—				
90	17·	4·1	—	200	84·	9·2	
100	21·	4·6	—	250	131·	11·5	
107	24·	4·9	5·0	300	189·	13·8	
120	30·	5·5	5·0 weak. 6·0 strong.				

Having established by experience the best size for a heliotrope upon a line of a given length, I obtained the following formula, based upon the general law of optics, for determining the size for any required distance: $x = d^2 \times \cdot 0021$, where x is the area of the required heliotrope *in square inches*, d the given distance in miles.

In the smaller heliotropes the amount of light cut off by the skeleton vane bears an undue proportion to the size of the mirror, and this must therefore be taken into consideration. I use the smallest skeleton vanes compatible with stiffness. If for any cause a larger heliotrope is needed on a given line, and under favorable circumstances the image appears too bright, the area of the mirror may be readily reduced upon a preconcerted signal, by affixing an open frame of tin or even of paper upon the outer edges of the mirror.

14. *On the Artificial Formation of the Diamond.*—The last number of the Proceedings of the Royal Society (No. 201), contains a preliminary notice by Mr. J. B. Hannay of the process by which he seems to have succeeded in obtaining crystallized carbon identical with the diamond. The following is an extract.

"When the carbon is set free from the hydrocarbon in presence of a stable compound containing nitrogen, the whole being near a red heat and under a very high pressure, the carbon is so acted upon by the nitrogen compound that it is obtained in the clear, transparent form of the diamond. The great difficulty lies in the construction of an inclosing vessel strong enough to withstand the enormous pressure and high temperature, tubes constructed on the gun-barrel principle (with a wrought iron coil), of only half an inch bore and four inches external diameter, being torn open in nine cases out of ten.

"The carbon obtained in the successful experiments is as hard as natural diamond, scratching all other crystals, and it does not affect polarized light. I have obtained crystals with curved faces belonging to the octahedral form, and diamond is the only substance crystallizing in this manner. The specific gravity is as high as 3·5. The crystals burn easily on thin platinum-foil over a good blowpipe, and leave no residue, and after two days' immersion in hydrofluoric acid they show no sign of dissolving, even when boiled. On heating a splinter in the electric arc, it turned black—a very characteristic reaction of diamond.

"Lastly, a little apparatus was constructed for effecting a combustion of the crystals and determining their composition. The ordinary organic analysis method was used, but the diamond crystals were laid on a thin piece of platinum-foil, and this was ignited by an electric current, and the combustion conducted in pure oxygen. The result obtained was that the sample (14 mgrms.) contained 97·85 per cent of carbon, a very close approximation, considering the small quantity at my disposal."

II. Geology and Mineralogy.

1. ***Sketches of the Physical Geography and Geology of Nebraska;*** **by Samuel Aughey, Ph.D., LL.D., Professor of Nat. Sci. in the Univ. of Nebraska. 326 pp. 8vo. Omaha, Nebraska, 1880.— These "sketches" contain a well-arranged and carefully prepared description of the region of Nebraska, as regards its topography, climatology, drainage and geology, and a general account of its flora and fauna. We cite the following facts from it:**

The State has a length (maximum) from east to west, of 418 miles. The average elevation of the eastern half is 1,700 feet, of the western 2,612 feet. The mean elevation of the State is 2,312 feet. The ascent for 100 miles west from Omaha is 5½ feet a mile; for the second 100, 7 feet; the third 100, 7½ feet; the fourth, 10½ feet.

The increasing size of the streams and the increasing number of springs during the past fifteen years indicates an increased rainfall. Professor Aughey attributes this greater amount of rains to the turning up of the soil for cultivation, which has rendered it, on an average, nine-fold (by his experiments) more absorptive of the water from rains. The water that falls on the hard original soil of the prairies mostly flows off into the canyons and streams; while the broken soil, like a huge sponge, takes it all in. At the time of the first settlement of the state the average rain-fall was 20 inches and the part absorbed probably not more than 5 inches; now it is 32 inches, and not less than 24 are absorbed. The great thickness of the soil—of all depths to 200 feet in the lœss regions —gives this sponge its great magnitude and power.

Professor Aughey discusses well the facts relating to the lœss and its origin. He shows that Richthofen's wind-drift theory finds no support in the character of the Nebraska deposits. He states that the Missouri river in the period when the lœss was being deposited must have been from 5 to 30 miles in breadth; and that the Platte, the Niobrara and Republican spread over their respective plains in the same way. He mentions the occurrence of stratification, and in some parts of thin lamination; of transitions into or alternations with sandy beds; in its lower part, the occurrence of fresh-water as well as land shells, and various other facts bearing on the question of origin. He speaks of examining the silt after a flood on the Missouri four miles below Dakota City, and of obtaining, in 1871, of existing kinds brought down by the river, 35 species of land shells and 20 of fresh-water species. The lœss of eastern Nebraska is over 3,000 feet below its highest point on the west line of the State. But this height, so far as not due to a small eastward pitch in the waters, is accounted for by a change of level.

The remains of life found in the lœss are, in addition to the molluscan, those of the rabbit, gopher, otter, beaver, squirrel, deer, elk and buffalo. Bones of the mastodon and elephant are

also often found, especially in Lancaster county. In Lincoln, situated "near the western shore of the Missouri lake of the period," "they have been found in at least twenty wells." Professor Aughey states that in 1872 he found in the lœss, three miles east of Sioux City, in a railroad cut, an Indian arrow-head; and he has since found arrow-heads, spear-heads and flint-chips at other points: in the bluffs back of Jackson, in 1874, 2½ miles southeast of Omaha, in a railroad cut, 15 to 20 feet below the top of the lœss; east of the Republican Forks, 14 feet below the surface, underneath the second bed of black soil. "It appears then that some old races lived around the shores of this lake, paddled their canoes over its waters, and accidentally dropped their arrows in its waters or let them fly at a passing water fowl." The rising of the land "closing the lœss period first clearly outlined the present rivers of Nebraska."

At the present time the rivers have very wide river-bottoms, ranging from one to ten miles or more. Above these there are one or more terraces: a lower, usually 3 to 6 feet above the river-bottoms; a second, 12 to 25 feet; and a third, of varying elevation. The bottom-lands are seldom overflowed in any part at the highest floods.

2. *Silurian age of the Crystalline rocks of Eastern Pennsylvania and Hudson River age of the Hydromica Schists.*—Mr. Charles E. Hall has an important paper on this subject in the Proceedings of the American Philosophical Society for January, 1880, together with a map illustrating it. He first mentions the occurrence of the fossil seaweed *Buthotrephis flexuosa*, of probably Hudson River Age, in the Peach Bottom roofing slates of York County, Pa., announced by Prof. Frazer. The rocks of the region in order of age are stated to be:

(1) Granitoid, syenitic, hornblendic, micaceous and quartzose rocks, older than Silurian, that is, of Archæan or Azoic age: one division extending in a southwesterly belt across Bucks and Montgomery Counties, as far west as Chestnut Hill, Philadelphia; a second, from the vicinity of the last mentioned locality, westward across the Schuylkill, and covering much of northern Delaware County.

(2) Potsdam sandstone and conglomerate, with some schistose beds resting unconformably on the preceding; over these, dolomites, crystalline limestones (the dolomites below the limestones) hydromica schists, the upper part of which group has afforded Trenton fossils at Buckingham, Bucks County; and also hydromica schists, quartzose schists, chloritic schists, with occasional beds of quartzite and serpentine, which are of the Hudson River group, and flank the Chester Valley on the south from some point not far east of the Schuylkill River throughout the entire length of the valley; and micaceous garnetiferous schists with limestone, in the southern central portion of Chester County, resting upon the last-mentioned hydromica schists. These Hudson River schists are those that have been called Taconic. Details are given

illustrating the conformability of all these schists and limestones. Together they occupy the region between the Archæan and the Triassic area.

(3) Mica schists, hornblendic, garnetiferous and talcose schists of Philadelphia, with soapstone and serpentine, which are described as resting unconformably on the preceding. A large part of this area is on the southeast side of the Archæan between it and Delaware River. The nonconformity "may be owing to faulting, but they [the rocks] are nevertheless more recent."

The serpentines of Radnor township in Delaware County, and those of Easttown, Willistown, East and West Goshen are spoken of as "undoubtedly altered beds of the South Valley Hill slates or Hudson River slates." The serpentines of Lancaster County are referred to the same age, and also probably those of Chester County.

3. *On the Carboniferous Volcanic Rocks of the Basin of the Firth of Forth: their structure in the field and under the microscope;* by ARCHIBALD GEIKIE, Director H. M. Geol. Survey of Scotland. 82 pp. 4to, with three plates, containing a geological map; sections of strata, and microscopic views of slices.—This elaborate paper, after its historical introduction, presents an account of six "volcanic districts" within the region of the Basin of the Firth of Forth, and describes in detail the positions and relations of the beds, and the character of the rocks. The eruptive rocks are divided into (1) Augite-feldspar rocks (divided into diabases or the granitoid variety, dolerytes and basalts); (2) Olivine augite-serpentine rocks, seen only at two localities; (3) Feldspar-magnetite rocks, or the porphyrites, which played an important part among the earlier eruptions of the Carboniferous period; and (4) Felsitic rocks, constituting a few dikes; and besides these there are fragmental rocks or tufas.

4. *Contributions to the Geology of Eastern Massachusetts;* by WM. O. CROSBY. Occasional Papers of the Boston Society of Natural History, Vol. III. 288 pp. 8vo, with five plates and a colored geological map.—Mr. Crosby's papers are very important contributions to the geology of Eastern New England. The rocks are described in detail, both as to their kinds and distribution, and facts are given bearing on the question of age, and illustrating many points in geological science. Among the interesting questions discussed is that of the age of the conglomerate, associated with the Primordial slate, the area of which two formations extends three to four miles north of Boston, eight to ten west (and in lines still further), and six to seven miles south. Mr. Crosby concludes that the conglomerate probably underlies the slate. He remarks that the conglomerate contains pebbles of the Shawmut amygdaloid, a rock associated with it to the southwest. The maximum thickness of the conglomerate is made about 1,000 feet, and that of the slate nearly the same. Both are stated to be unconformable with the crystalline rocks adjoining, which are referred to the Archæan.

5. *Eleventh Annual Report of the U. S. Geological and Geographical Survey of the Territories, embracing Idaho and Wyoming, being a report of progress for the year* 1877; by F. V. Hayden, U. S. Geologist. 720 pp. 8vo, with numerous plates, seventy of them illustrating rock sections, topography, scenery, tufa formations, and ten of fossils, besides six of maps. Department of the Interior. Washington, 1879.—This thick volume, just out of press, bears evidence of the great activity and success in the explorations carried forward under Dr. Hayden. It is made up of a general report by Dr. Hayden, reviewing the work of the year; special geological reports by F. M. Endlich, O. St. John, and Dr. A. C. Peale; paleontological, by C. A. White; and topographical, by A D. Wilson and Henry Gannett.

With more space at command, large citations would here be made from the volume.

6. *Earthquake of San Salvador, of December* 21–30, 1879.—A recent letter from Mr. W. A. Goodyear, now Director of a Governmental Mining and Geological Survey of San Salvador, states that more than 600 earthquake shocks were felt there within the last ten days of 1879. They were heaviest about Lake Ilopango, where he was on the 23d and until the 27th, when a shock came, as he writes, "that broke the telegraph wire, and made the ground on which we stood a perfect network of cracks, opened new springs of water, increased the rivulets in the vicinity to ten times their volume, muddied the waters of the lake in many places, and rolled hundreds of thousands of tons of rocks and debris down the steep hills in the shape of land slides." "As a sequel to the earthquakes, on the night of January 20th and 21st a new volcano appeared in the center of the Lake of Ilopango. This volcano does not yet (Feb. 1st), show more than four or five acres of new rocks above the water, and has not yet discharged any liquid lava. But it is growing, and its clouds of steam are seen every day from the Capital, rising 1,000 feet or more above the lake."

7. *Oil-sands of the Bradford or Northern oil-district of Pennsylvania compared with those of the Venango or Western District.*—Mr. C. A. Ashburner, of the Geological Survey of Pennsylvania, states, in a paper read before the American Philosophical Society on March 5, that the oil-sands (or sandrocks) of the Bradford region are about as coarse as ordinary beach-sand, even in grain, of constant thickness, and widely spread, while those of the Venango district vary from coarse to fine, and abruptly also in thickness and composition; the bottom layer, which is the most productive, is in part a fine micaceous mud-made rock, yielding only a trace of oil. The former are of the Chemung group, the latter of the Red Catskill (No. IX of the Pennsylvania survey). In the Bradford district during the year 1879, 2536 wells were drilled to the Bradford oil-sand, of which only 3 per cent were *dry holes*, while in the Venango district, during the same year, 475 wells were drilled (in the Counties of Warren, Venango, Clarion and Butler), and 122 were *dry holes*, or 25·7 per cent.

The largest *individual* wells have been opened in the Venango district, but the average yield has been greatest in the Bradford; some of the former having produced 2,000 to 3,000 barrels of oil per day, while the largest of the latter have not exceeded as many hundred.

8. *Giesecke's Mineralogiske Rejse i Grönland*, ved F. JOHNSTRUP; med et Tillæg om de Grönlandske stednavnes Retskrivning og Etymologi af Dr. H. Rink. 372 pp. 8vo, with 3 plates. Copenhagen, 1878.—This work gives the diary of Carl Ludvig Giesecke during his travels in Western Greenland from 1806 through 1813, or about eight years. Giesecke was the first to call attention to the mineralogical and geological nature of the part of the country inhabited by Europeans, and this gives an especial interest to his observations. His travels extended along the western coast between latitude 60° and 73° north, and although his attention was especially directed to the collection of minerals and rocks, he devoted much time also to the geography and ethnography of Greenland. Among the new minerals discovered by him are eudialyte, arfvedsonite, allanite, giesekite, fergusonite, sapphirine; he also described the method of occurrence of cryolite. During his life he published but little, and it is only now that his diary, which was sent each year to Copenhagen as a report of the results of his investigations, has been published.

9. *Explorations in the Interior of Greenland in* 1878; by Lieutenant JENSEN. (Meddelelser om Grönland udgivne af Commissionen for Ledelsen af de geologiske og geographiske Undersögelser i Grönland; part I, 195 pp. 8vo, with 6 plates and 3 charts. Copenhagen, 1879.)—This volume contains an account of the explorations carried forward in Southern Greenland, (lat. 62° 15′ to 64° 30′) by Lieut. Jensen and his associates during 1878. His labors form a part of the general plan for the geological exploration of Western Greenland adopted by the Danish Government in 1876 and prosecuted actively since that time; a work in which the geologist Steenstrup has taken a prominent part, especially in Northern Greenland.

A summary of the results of Lieut. Jensen and of the relations of these explorations to those which preceded him, from the time of Giesecke down (see above) is given at the close of the volume by Prof. Johnstrup. From it the following facts are extracted. The continental ice of Southern Greenland has been hitherto an almost absolutely unknown region, the only extended journeys upon it are those of Dalager in 1751, and of Nordenskiöld in 1870. Lieut. Jensen, with great courage and perseverance, has succeeded in penetrating a distance of about forty-five English miles from the coast, starting from the "Frederickshaab Isblink" (lat. 62° 30′). A peculiar interest attaches to the expedition since at the farthest point of the journey inland, he reached a series of isolated rocky summits, emerging like islands above the continental ice (they are called *Jensen's* "*Nunatakker*). From these peaks, 5000 feet above the sea level, and

surrounded now, as they must have been for a vast period, by the fields of continental ice, a large collection of plants (fifty-four species) was obtained, and some few animals were also found. The ice on the east side of the "Nunatakker" has an altitude of 1570 meters above the sea, and must have a considerable thickness, since from the western edge it rises inland at a small angle (0° 49′). These isolated peaks exert a decided influence on the movement of the ice, so that in places its direction is reversed. In the midst of the continental ice the planes of dislocation are nearly perpendicular to the surface, but on the edges and about the "Nunatakker" they are inclined where the melting is greater and there results an increase in velocity in the upper parts of the ice. The crevasses are in part perpendicular and in part parallel to the direction of the movement, according to the nature of the surface underneath, and whenever the ice can expand fan-shaped they are radial and tangential. In the neighborhood of rocks, both of the interior peaks and of the coast, the surface of the continental ice is impregnated with fine clay and sand which are brought upon it by the tempests, and which the streams carry off into cavities of the ice mass. At one spot on the edge of the ice a pyramid of ice, occasioned by this accumulation of clay, was observed which was nearly sixty feet high. Moraines of different forms were noted on the ice in the region of the "Nunatakker" and they are considered as ground and terminal moraines. They form often curved and semi-circular lines and consist of much rounded blocks of stone of no great size. These, as they advance, fall into the crevasses, and thus the moraine disappears.

This volume contains a record of the astronomical and meteorological observations made during the expedition; also notes upon the Geology of the portion of Greenland explored by M. Kornerup; and a list of the plants collected, this last is given by M. Lange. The colored plates give a vivid impression of the great ice field over which the party traveled.

10. *Geological Chart of Belgium and the neighboring Provinces;* by A. DEWALQUE, Brussels.—This colored geological chart of Belgium measures twenty-four inches by twenty. It is a beautiful specimen of chromo-lithography. The areas of nearly fifty different formations are represented by colors and etching, ranging from the Pliocene through the whole geological series to its bottom, and including also some eruptive and other crystalline rocks.

11. *Edible Earth from Japan;* by E. G. LOVE, Ph.D. (Communicated).—It is somewhat surprising to find that the Japanese, in part even, are addicted to the eating of earth. The following analysis shows the composition of an earth eaten to a considerable extent by the Ainos. The clay, occurring in a bed several feet in thickness, is found in the small valley of Tsietonai (eat-earth-valley) on the north coast of Yesso. It is of a light gray color and very fine in structure.

SiO_2	Al_2O_3	Fe_2O_3	Mn_2O_3	CaO	MgO	K_2O	Na_2O	SO_3	P_2O_5	H_2O*	
67·19	13·61	1·11	0·07	3·89	1·99	0·23	0·75	0·19	tr.	11·02	= 100·05

* With volatile matter.

The "volatile matter," which was very small in amount, consists of the fragments of the leaf of some plant which the people intentionally mix with the clay for the aromatic principle it contains, or which was accidentally picked up when the specimen was taken. On treating the leaf with ether and evaporating, I obtained some oily matter of an agreeable odor, but too small in amount to enable me to determine its nature. The Ainos think the earth contains some beneficial substance, and eat it on this account and not because it is a necessity with them. They have meat and an abundance of vegetable food. The clay is eaten in the form of a soup. Several pounds are boiled with lily roots in a small quantity of water and afterwards strained. The Ainos claim that the soup thus prepared is very palatable.

12. *On Conodonts, etc.*—The author of the monograph on Conodonts, quoted from in the last (April) number, p. 327, is Mr. George Jennings Hinde, not Hyde as there printed.

III. BOTANY AND ZOOLOGY.

1. *Genera Plantarum ad Exemplaria imprimis in Herbariis Kewensibus servata definita;* auct. G. BENTHAM et J. D. HOOKER. Vol. iii, part I, pp. 459 (including temporary index). London, Reeve & Co., &c., 1880.—The first part of the first volume was issued in the summer of 1862. In February of the present year, the portion of the third and last volume containing the Monochlamydeous Dicotyledons and the Gymnosperms makes its appearance, so we may hope that the completion of the Phanerogamia, with which this great work may be expected to close, is not far distant. But the death of General Munro, who would have helped greatly in the grasses, is a drawback. It should be understood, however, that no order and no group of plants whatever has been taken from the hands of any collaborator or monographer. The work has all been done from nature, at first hand by the authors themselves,—a thing that has never been done before in a Genera Plantarum, since that of Jussieu, and hardly then.

This notice may be confined to indication of changes, such as may concern North American botany.

The monochlamydeous (otherwise called apetalous) series of orders begins with the *Nyctagineæ*. The leading genus *Mirabilis*, being still allowed to embrace *Quamoclidion*, their great difficulty was in keeping it clear of *Oxybaphus*. In this country we had regarded the anthocarp as most distinctive; but the present work prefers the form of the perianth and the texture of the involucre, but with hardly an improved result. *Senkenbergia* (*Tinantia*), which we had reduced to *Bœrhaavia*, is well restored.

The *Illecibraceæ* (*Paronychieæ*), excluded from their association with the *Caryophyllaceæ*, here find their natural place next the *Amarantaceæ*, and *Achyronychia*, which is referred to it, has a second species, one of the new things in the recent Mexican collection of Parry and Palmer.

In the succeeding order, *Amarantus* is restored to its old limits, including not only *Euxolus* and *Mengia*, but also *Amblogyne*. *Acnida* properly takes in *Montelia*, and a bad oversight of Gray's Manual is corrected. As was to be expected, *Cladothrix* of Nuttall takes generic rank.

Chenopodiaceæ are considerably extended, by some genera which were ambiguous between this and the preceding order, and still more by the inclusion of the *Baselleæ*. *Sarcobatus* forms a subtribe. The old difficulty of limiting *Chenopodium* and *Blitum* is effectually surmounted by reducing the latter to one of the five sections of the former. *Teloxys* is of course a *Chenopodium*, and *Obione* is not distinguished even sectionally from *Atriplex*. The important distinction between the plane-appressed fructiferous bracts of *Atriplex* and its allies, and the conduplication and union of these bracts in *Suckleya* and the three genera associated with it upon the establishment of the latter genus, is not as prominently exhibited as it would have been by the adoption of the subtribe *Eurotieæ*.

Batis, with a single species, stands for an order *Batideæ*.

Polygonaceæ are marked by the introdnction, between the *Eriogoneæ* and the *Eupolygoneæ*, of a tribe *Kœnigieæ*, which besides the typical genus and its evident relative *Pterostegia*, is made to include *Lastarriæa*, *Nemacaulis*, and *Hollisteria*, whose affinities are more Eriogoneous. Sereno Watson's natural arrangement of *Eriogonum* is adopted; but *Centrostegia* is kept distinct from *Chorizanthe*.

The *Piperaceæ* include the *Saurureæ*, and *Anemopsis* is reduced to *Houttynia*.

The great order *Laurineæ* is thoroughly revised; but all that concerns us is, that our Californian Laurel is removed from *Tetranthera* or rather *Litsea* Lam., and one of the two generic names which Nuttall applied to it is used for this at length well characterized genus, viz: *Umbellularia*,—not a good name, but it will serve.

In *Santalaceæ*, the still incompletely known genus *Darbya* is well removed from *Comandra*, to which DeCandolle referred it: whether it is here rightly joined to *Buckleya* can be known only when female flowers or fruit are discovered. These are special desiderata. The plant (a low shrub) is to be sought between Lincolnton, North Carolina, and Macon in Georgia!

The immense order *Euphorbiaceæ* has been studied anew, the great labors of Baillon and of J. Müller duly weighed, and the result is that six tribes are admitted under simple characters, and the ample sixth tribe, *Crotoneæ*, is divided into eight subtribes. The views adopted have been expounded by Mr. Bentham in a memoir, some notice of which has appeared in this Journal. The genera nearly reach 200, and there are over 3000 described species. We have soon to add a North American representative of the *Stenoldieæ*, and of the biovulate division, connecting with the *Phyllantheæ* *Reverchonia* of northwestern Texas and adja-

cent Arkansas. The male flowers of it are still wanting. Nuttall's *Alphera* is a section of the genus which is here given as "*Argithamnia* Swartz, Prodr.," but which begins as *Argythamnia* of Patrick Browne, a contemporary of Linnæus.*

The order *Urticaceæ* is adopted in the older and extended form, including the *Ulmeæ*, *Celtideæ*, *Cannabineæ*, *Moreæ*, *Artocarpeæ*, etc., as tribes. A main ojection to this view is surmounted by regarding the pistil in all of them as monocarpellary, and the two stigmas of Ulmus and the like as divisions of one or half-stigmas, after the analogy of many *Euphorbiaceæ*. *Ficus* is restored to its original proportions.

The ambiguous or anomalous genus *Leitneria* of Chapman, of which there is said to be a second species in Texas, stands as an order *Leitnerieæ*, which we crave leave to write *Leitneriaceæ*.

The *Cupuliferæ* are made to include not only the *Coryleæ* but the *Betulaceæ* also—which seems to be going too far.

Empetraceæ and *Ceratophylleæ* are among the supplementary orders which close the series. The compound pollen-grains of the former, after the Ericaceous type, have not been noticed.

The *Gymnospermeæ* consist of the *Gnetaceæ*, *Coniferæ*, taken in the largest sense, and *Cycadaceæ*. This notice is already too long to admit of an analysis of the treatment of the most important order *Coniferæ*, which is to a good degree original; and some points need to be pondered, before pronouncing as

* The history of this name and of its changes is curious and raises a nice point in the application of the rules of nomenclature. Patrick Browne founded it in the year 1756, wrote the name *Argythamnia*, but gave no etymology. It is pretty clearly inferable that he had ἄργυρος in view, that he should have written *Argyrothamnia*. We suppose that he shortened it in a way at that time and since not very uncommon, remembering the warning of Linnæus against *verba sesquipedalia* Unnecessary as it was in this case, it was a trivial curtailment compared with Rafinesque's *Nemopanthes*, razeed from *Nemopodanthes*, which no botanist has attempted to restore to its full proportions. Adanson adopted the genus under Browne's name in 1763. So did Swartz in his Prodromus in 1788.

Argithamnia, however, is the form adopted by Swartz in his Flora, in 1797, remarking that Browne derived the first part of the name either from ἀργός, white, or from ἀργυρεος, silvery. But if from the latter, Swartz should have written *Argyreothamnia*, if from the former *Argothamnia*.

Acting doubtless on the principle that if the orthography of a name might be changed to make it correct, it might be further changed to render it quite correct, Sprengel in his turn wrote it *Argothamnia*, and Mueller of Argan, *Argyrothamnia*. Now all these changes from first to last violate the rule (which is not without exceptions) that botanical names should be retained in their orginal form. At least mere improvement is no warrant for alteration. Mistakes may, indeed, be corrected. Thus Nuttall's genus *Wisteria*, in honor of *Dr. Wistar*, was properly corrected to *Wistaria*, in conformity with the rule that personal names should retain their orthography as nearly as possible. But upon our theory *Argythamnia* was not a mistake. Bentham and Hooker have acted upon the principle of preserving the origiual orthography; only they took the genus to originate with Swartz, passing by Browne, evidently because he did not use Linnæan specific names, though that could not affect the worth of his genera. If they had adopted the genus from Browne's original, or from Adanson who took it up in 1763, or from Swartz's Prodromus (1788), or from Jussieu in 1789, eight years before Swartz in his Flora wrote *Argithamnia*, we cannot doubt that they would have held to the original form, *Argythamnia*.

opinion. Suffice it to remark that the three classical suborders are suppressed (our authors are not fond of suborders), and the whole are disposed under six tribes, the leading characters of which are taken from the direction of the ovules. Two of them, the *Podocarpeæ* and the *Araucarieæ*, which, like the *Abietineæ*, have reversed ovules, do not here concern us.

Thuya is written in this unclassical form in which it came into botany through the old herbalists, adopted by Tournefort and Linnæus. It is made to include not only *Thuyopsis* and *Biota*, but even *Chamæcyparis* (*Retinospora*, etc.), which the arboriculturists will hardly like. We must wonder it was not extended to *Libocedrus* also, at least to the species of the northern hemisphere.

Taxodium, we are glad to notice, takes in *Glyptostrobus*. It is also gratifying that *Sequoia* goes into the same tribe, on the strength of the ovules being ascending or at least porrect at the outset, though the seed is reversed. The noteworthy fact comes to light that *Athrotaxis* of Tasmania is very nearly related to *Sequoia*. It should not be surprising that a type so early developed and widely diffused of old should have representatives in the southern hemisphere.

In the *Abietineæ*, the received genera are *Pinus* in the restricted sense, *Cedrus*, *Picea* (for the Firs, i. e. Balsam Firs), *Tsuga* (Hemlock Spruces and *T. Williamsonii*), *Pseudotsuga* (the Douglas Spruce), *Abies* (the true Spruces), *Larix*, the Larches. To the latter, rather than to *Cedrus*, *Pseudolarix* is appended, awaiting a knowledge of its male flowers.

Many and profound are the thanks due from all systematic botanists to the authors of this Genera Plantarum. A. G.

2. *On the Popular Names of British Plants, being an Explanation of the Origin and Meaning of our indigenous and most commonly cultivated Species.* By R. C. A. PRIOR, M.D., etc. Third Edition. London, F. Norgate, 1879. pp. 294, 12mo. —This book, full of interesting and curious lore, must have had the success it merits, for it is now passed to a third edition. The preceding one was issued in 1870. There is no specification of the changes which have been made in it, and the increase in size is of only four pages. But the scrupulous carefulness of the author warrants the assumption that it has received all needful supervision.

What we here need is a supplement to Dr. Prior's volume, recording the changes which have occurred in the application of English popular names to North American plants, and giving the history and application of our indigenous plant-names. A. G.

3. *Botanical Necrology:*—

JOHN CAREY—of whom few of the botanists of our day can have a personal remembrance—died at Blackheath, near London, March 26, ult., in the 83d year of his age. He came from London to the United States, in the spring of 1830, accompanied by three young and motherless children and by his brother, Samuel

T. Carey, who was also addicted to Botany. Both, we believe, were Fellows of the Linnean Society, and were near friends of Thomas Bell, afterwards the president of that society, who also lived to a good old age, dying only a few weeks earlier than the subject of this notice. Samuel T. Carey remained in the city of New York, in active business, and so was only an amateur botanist. His brother John, went into the country, first to Towanda, in the northern part of Pennsylvania, then to Bellows Falls, Vermont, where, giving much of his leisure to botanical pursuits, he resided until the year 1836, when he removed to New York, upon the entrance of his sons into Columbia College. He did not enter into business, but his administrative talents and great worth were so appreciated that he was at various times called to very responsible temporary positions. These positions, although unsought, were not unwelcome, for no small part of the moderate property he brought from England had been lost in investments made through reliance upon the honor and probity of defaulting States.

From the time of his arrival in the United States down to the year of his return to England in 1852, most of his leisure was given to botany, and much of it in companionship with the present writer, who was generously and greatly assisted by him in many critical studies. The proofs of the writer's first botanical book were revised by him; and to the first edition of the Manual of Botany Mr. Carey contributed the articles on *Salix* and on *Carex*, at that time the two most difficult parts of the work. In the year 1841 the two made a botanical journey together into the mountains of North Carolina, extending to the Grandfather and to the Roan, though a mishap upon the former mountain prevented Mr. Carey from reaching the latter. After the establishment of the writer at Cambridge, Mr. Carey was his frequent guest and an invaluable companion. His botanical career may be said to have closed in the year 1852. In that year he returned to England, alone, having successively lost his aged mother and his two younger sons, and seen the older son happily established in marriage. He engaged for several years in business, in connection with a friend of his youth, whose daughter he soon married, but lost within three years, after the birth of the second of two children, the solace and comfort and care of a serene old age, who survive to perpetuate his name, as we trust, on that side of the ocean also. Mr. Carey's first herbarium was destroyed by a calamitous fire in New York, at the time of the death of his youngest son. American botanists vied with each other in the endeavor to repair this serious loss, and another large collection of United States plants was formed, critically studied, and carefully annotated. This was presented to the Kew Gardens Museum eleven years ago. Several species of United States plants commemorate this honored name, among them a Saxifrage, which was discovered upon the excursion to the mountains of North Carolina, where the survivor of the party re-collected it last summer. The almost sole survivor of a botanical circle, of which Torrey was the center,

sadly but serenely pays the tribute of this brief note to the memory of a near and faithful friend, an accomplished botanist, a genial and warm-hearted and truly good man. A. G.

COE F. AUSTIN died at his home in Closter, New Jersey, on the 18th of March, ult., in the 49th year of his age. He was one of the original members of the Torrey Botanical Club, in which he will be much missed, and he was for some years, during its founder's lifetime, the curator of the Torrey herbarium. He was a very zealous and sharp-sighted botanist, and he followed his bent and pursued his investigations under many difficulties and privations. He contributed the article *Lemnaceæ* to Gray's Manual in 1867, has described several new species of Phænogamous plants; but has for a long while devoted himself most untiringly to Muscology, in which he was an adept. In a knowledge of *Hepaticæ* he was unrivalled in this country, and he fortunately enjoyed good opportunities for their study, the late Mr. Sullivant having long ago made over to him all his books and specimens relating to this order. He was to prepare a manual of the North American Hepatic Mosses, and perhaps has in good part done so, though it is to be feared that it is not completed. His last botanical work, finished upon the eve of fatal illness, was the description of the *Hepaticæ* of California for the second volume of the Botany of California, now in press. Several years ago he published *Exsiccati* of the Mosses of the Atlantic United States, and later sets of our *Hepaticæ*, embodying an immense amount of labor in their collection—in travel, mostly on foot, through the Southern, Eastern and Middle States—no less than in their investigation. We believe that these sets remain in good part unsold; and it is hoped that they will now be offered to botanists and secured by them to their advantage, and to the benefit of the family of the deceased. No botanist ever had a quicker eye for the detection of differences than Mr. Austin, or a more unreserved devotion to a favorite pursuit. A. G.

4. *On a collection of Crustacea from Virginia, North Carolina, and Florida, with a revision of the genera of Crangonidæ and Palæmonidæ;* by J. S. KINGSLEY. (From Proc. Acad. Nat. Sci. Phila. for 1879, pp. 383–427, pl. 14. No date: received March, 1880).—This, the longest of Mr. Kingsley's papers on American crustacea, notices about 100 species (9 of which are described as new), and is the most complete list yet published of the crustacea of the coast of the Southern States. It is based upon collections made by Prof. Webster of Union College. Decapoda only are included and of these the Pagurioidea are omitted. The paper covers partially the same ground as Mr Kingsley's "List of the Decapod Crustacea of the Atlantic coast, whose range includes Fort Macon" (op. cit., 1878, pp. 316–330), and is a marked improvement upon it. Attention should be called, however, to a few of the mistakes noticed in a cursory examination. In extending the range of *Leptopodia sagittaria* to Chili on the authority of A. Milne Edwards' identification of *L. debilis*

with that species, the author overlooks Milne Edwards' statement in the same paragraph that *L. sagittaria* Edwards and Lucas is a distinct species for which the name *modesta* is proposed. *Actæa spinifera* (sp. nov.) appears to be *A. acantha* A. Milne Edwards, which has been well figured twice; and if not Milne Edwards' species it should have been compared with it rather than with *A. hirsutissima*. *Eupilumnus Websteri* (gen. et sp. nov.), figured and very briefly described from a single specimen wanting the chelipeds, is evidently not very closely allied to *Pilumnus* and is apparently based on a young specimen of *Domacea hispida*, which had already been reported from the Florida reefs by Stimpson. Moreover, the name *Eupilumnus* is preoccupied, having been used (according to the Zoological Record for 1877) by Kossmann for a division of the old genus *Pilumnus*. In attempting, in a foot-note on p. 405, to "straighten the synonymy of two species of *Petrolisthes*," the confusion in the synonymy of one of the species is increased. *Petrolisthes Helleri* is proposed for *Porcellana Danæ* Heller (non Gibbes), regarded by Heller as the same as *Porcel. armata* Dana (non Gibbes). Dana, however, discovered that his name *armata* was preoccupied and, in the appendix to his great work, p. 1593, and in the explanation to the plates, substituted *spinuligera* for his species, though this has been overlooked by Stimpson and Heller as well as by Kingsley. The reason for the reference of the species to *Petrolisthes* is not apparent, for Stimpson retained Dana's species in the restricted genus *Porcellana* and, at least, it has no appearance of being a *Petrolisthes*.

Under Caridea there is a useful revision of the genera of Crangonidæ, Atyidæ, and Palæmonidæ, though one is occasionally left in doubt as to the limits of the genera adopted; as in the case of the first genus, *Crangon*, which is said to include *Steiracrangon* Kinahan, while no mention whatever is made of the same author's *Cheraphilus*, which has recently been adopted by G. O. Sars and by Miers. A peculiar misuse of "ibid.", which the proof-reader ought to have corrected, might be overlooked did it not recur so persistently in nearly all of Mr. Kingsley's papers. S. I. SMITH.

5. *The Crayfish: an Introduction to the Study of Zoology*; by T. H. HUXLEY. 371 pp. 8vo. New York, 1880 (D. Appleton & Co.)—This last volume of the International Scientific Series is far more interesting than ordinary text-books of zoology and well-deserving of careful study. Though it treats specially of the natural history, physiology, morphology, comparative morphology, distribution, and origin of crayfishes, it admirably fulfills the author's desire, as expressed in the preface, "to show how the careful study of one of the commonest and most insignificant of animals, leads us, step by step, from every-day knowledge to the widest generalizations and the most difficult problems of zoology." A large part of the excellent wood-cut illustrations are new, and many are unusually beautiful for a work of this class. The figures (after Bate) on page 282, are of *Carcinus mænas*, not *Cancer pagurus* as labeled. S. I. SMITH.

IV. Miscellaneous Scientific Intelligence.

1. *On the movement of Glaciers.*—A series of careful measurements has been made by K. R. Koch and Fr. Klocke on the Morteratsch glacier in Eastern Switzerland. Their object was a somewhat different one from that of previous observers, as they desired to determine whether in its general downward course the movement was uniformly forward, or whether discontinuous or at times backward. The investigations were limited to the observation of the movement of a point of the surface in a vertical plane parallel to the length of the glacier. The method employed was as follows: Two scales, perpendicular to one another, were so attached to the glacier that one stood vertical and the other horizontal, and their movements in their respective directions were noted by means of a fixed telescope at a distance.

The observations were carried on in the day time from August 28 to September 6 (1879). The station was situated on the west side of the glacier, about a mile from its lower end. It was favorably placed, both since it afforded a perfectly firm base for the telescope, and also because as at this spot the mass of the glacier is without any very considerable crevasses, either longitudinal or transverse, it was likely to be free from accidental variations. The stake to which the scales were attached was imbedded a foot and a half in the ice, and to prevent any melting at the spot a pile of ice a foot in height was made about it and then this covered with stones and gravel. A stake so planted remained perfectly firm and suitable for observations for some four days. The telescope was placed on the shore and protected from the sun. The two series of observations, carried on independently by each observer, were found to agree satisfactorily. The scales themselves were divided into half centimeters, but could be read by estimate to millimeters. As a control over the observations, and to prove that the movements were really those of the glacier and not of the rod itself, a second signal was planted in the ice near enough to the first to be included in the same field of view; it was found that the movements of both corresponded closely.

As examples of the results obtained, the measurements on September 3 and 4 are taken, the first was a perfectly clear and cloudless day, while on the second the sky was (especially in the morning) covered with cumuli, and the glacier only partially affected by the sun's rays. The results may be stated as follows: for scale I (35 meters from the edge of the glacier) the movement during the afternoon was slight, both horizontally and vertically, and this downward; later in the afternoon the movement diminished still more and finally ceased. During the night there was a movement of the point vertically upward and horizontally toward the valley. When the sun's rays first fell upon the ice, and from then to midday the movements were quite irregular, then the movement downward again began and the preceding effects were repeated.

The course of scale II, 90 meters from the edge of the glacier, was in part similar; that is, downward, horizontally and vertically, during the afternoon until 4 o'clock P. M., when it was stationary; on the other hand, during the night there was a strong backward movement (as much as 9·9 cm.), while vertically the movement was slight; from sunrise till midday as in the other case the movements were quite irregular. Similar results were obtained for another point situated about three-fifths of a mile higher up on the glacier.

The magnitude of the movements referred to will be seen from the following table, where the measurements are given in centimeters:

Hours, P.M.	Scale I.		Scale II.		Hours, A.M.	Scale I.		Scale II.	
	Horizontal	Vertical	Horizontal	Vertical		Horizontal	Vertical	Horizontal	Vertical
12 –12.30	+1·0	+0·6	+0·6	+0·2	6 – 7	+1·1	–0·1	–0·1	+0·3
12.30– 1	–0·2	±0·0	+0·5	+0·3	7 – 7.30	+0·6	+0·7	–2·1	+0·2
1 – 1.30	+0·1	±0·0	+0·5	+0·2	7.30– 8	–0·7	–0·3	+1·3	+0·8
1.30– 2	+0·2	+0·3	+0·6	+0·3	8 – 8.30	+2·3	+0·2	+2·1	–3·2
2 – 3	+0·1	+0·5	+0·9	+0·6	8.30– 9	+0·7	–0·3	+1·7	+3·5
3 – 4	+0·1	–0·1	+0·3	±0·0	9 – 9.30	–1·6	+1·2	+0·4	+0·8
4 – 5	–0·4	+0·2	±0·0	±0·0	9.30–10	–0·1	+1·1	+1·6	+1·0
5 – 6	+0·8	–0·1	–0·3	±0·0	10 –10.30	+0·7	+0·8	+2·3	+0·3
6 – 6 A.M.	+2·3	–1·0	–6·2	+1·0	10.30–11	+1·8	–0·4	–0·9	–1·0
					11 –11.30	–0·8	–0·2	+0·6	–0·2
					11.30–12	–0·5	+0·2	+0·8	+0·4

The observations on the following day correspond with those given except that the movements were less decided, connected, it is believed, with the less intense action of the sun's rays. The authors conclude that the movement of a glacier is far from being a uniform one; on the contrary, that one and the same point may have a motion now up, now down, both vertically and horizontally; further than this, that two points, at a distance of say 50 to 60 meters, may move at a different rate or even in different directions. They promise to carry on a similar series of observations, on a much larger scale, in the coming summer. These are in fact needed to establish the conclusions they draw, and to show that the observations have anything more than a local significance.— *Wiedemann's Annalen*, viii, 661.

2. *Volcanic action in Dominica.*—Dr. H. A. A. NICHOLS, who, we believe is Surveyor-general of Dominica, publishes in Nature (xxi, p. 372) an interesting letter describing an eruption in that island, shortly after 11 o'clock, A. M., on January 4. In the town of Roseau, the capital of the island, the phenomena consisted of a very heavy rain, accompanying a fall of light gray ashes, which covered the ground to the depth of a quarter of an inch. The Roseau river, which rises near the volcanic district, became a torrent of opaque white water. The scene of the eruption is about eight miles east of Roseau, and the ashes were blown westward by the tradewind, in a belt one and a half miles wide, and extending at least four miles out to sea. The crater

was visited on January 12, and was found to be an old one reopened in the forest about a mile southwest of the Boiling Lake, and to be some 600 feet deep. There was no earthquake, or at least none felt at Roseau. There was no flow of lava and not much evidence of fire, the eruption consisting of ashes and a gray mud, of which an enormous quantity was thrown out. The ashes, a pint measure of which without compression weighed 21 ounces and 15 drachms, were analyzed and found to contain ferric sulphide, magnesia, potash, soda, silicon, sulphur, carbon, oxides of iron, lead and alumina, with traces of other substances. C. G. R.

3. *The Microphone as a Seismometer.* (From a note in the Japan Gazette, quoted in Nature, xxi, p. 382.)—It appears that Professor MILNE of Tokio, has employed a special form of microphone to detect seismic tremors too slight to affect the ordinary seismometers. The similar use of the instrument by Professor M. di Rossi at Rome, two years ago, has already been noticed in this Journal, xviii, p. 159. Professor Milne's microphones, the special form of which is not described, were buried in pits round about the house and at a distance from roads, precaution being taken to exclude insects, which might disturb the sensitive apparatus. Under these circumstances, it would seem, that for sometime before an earthquake shock, the telephone gives signs of crackling in the earth as if it were exposed to an increasing strain, under which it finally gives way, and produces the vibration of the earthquake. C. G. R.

OBITUARY.

The naturalist Wm. Ph. Schimper died at Paris on the 20th of March. This celebrated author was born at Dosenheim, a village of Alsatia, Jan., 1808. At the time of his death he was Professor of Geology and Director of the Museum at the University of Strasburg.

As botanist he first gave especial attention to the study of Mosses. With the coöperation of Ph. Bruck and Th. Gümbel, two of his countrymen interested in the same kind of researches, he began in 1836 the publication of the *Bryologia Europæa* which occupied twenty years of his life. This work, a grand scientific monument, contains in six quarto volumes a detailed description of all the species of Mosses known in Europe, each illustrated by a full plate of figures, beautifully and exactly reproducing the characters of the divers parts of the plants and of their variations.

This production gave Prof. Schimper an eminent and well-merited place in the scientific world, for it was mostly the result of his own labors; Bruck having died long before it came to an end, while the coöperation of Gümbel was only temporary.

As a compendium to the Bryologia Europæa, Schimper published, in 1857, a memoir on the history of the *Sphagnum*, a quarto volume with fourteen plates, splendid illustrations of the germination, the progress of development, and characters of these plants of the family which he separated from the Mosses on account of their derivation from a prothallus like the Lichens.

In 1860 he published, in Latin, a synopsis of the European Mosses, preceded by a history of Bryology, and an exposition of the general characters of this order of plants, with systematic tables, maps representing the geographical distribution of the species, and plates for illustrations of the genera. A second greatly enlarged edition of the work was published in 1876.

The museum of Strasburg was already, when Schimper became its director, very rich in specimens of fossil plants. A large portion of the materials published by Brongniart in his *Végétaux Fossiles* had been derived from it. Schimper had there favorable opportunities to satisfy his taste for vegetable paleontology, a branch which had been part of his study in the German universities. An intimate friend and collaborator of Hugo Mohl, Alex. Braun, and other German physiologists of celebrity, he had acquired great proficiency in the anatomy of the vegetable organs. Already, in 1840, he published, with the coöperation of A. Niougeot, a monograph of the fossil plants of the *Grès bigarré des Vosges.* Later, in 1862, another work of the same kind, on the *Végétaux des Terrains de Transition des Vosges*, was prepared with the assistance of Kœchlin Schumberg, who furnished the geological exposition.

These were mere preparations for a much larger undertaking —that of the publication of his *Traité de Paléontologie végétale*, which in three large volumes gives the descriptions in Latin, with remarks in French, of all the species of fossil plants known to the time when it was finished, 1874, together with a folio atlas of one hundred and ten plates for illustrations of the more interesting vegetable types. This work demanded for its preparation long researches in the museums and private collections of fossil plants in Europe, and a critical review of all that had been published in paleo-botany. As an inexhaustible mine of materials referable to vegetable paleontology, the book has become an indispensable assistant to students and collectors of fossil vegetable remains.

A new manual of Paleontology, written in German and distributed in two parts, one for the animals by Karl A. Zittel, the other for the plants by W. P. Schimper, is yet unfinished. The half volume prepared by this last author and already published reviews the Thallophytes, the Bryophytes, and the Pteridophytes.

This short record of Prof. W. P. Schimper's productions cannot give an idea of the amount of work performed by this celebrated naturalist, during a career harassed by the most distressing and disheartening circumstances. It says nothing of the noble character of the man, who, always genial, kind and obliging to every one who needed his assistance, has left, as sincere friends to deplore his loss, all those who had intercourse with him.

L. LESQUEREUX.

Description of twelve new fossil species and remarks upon others, by S. A. Miller. 16 pp. 8vo, with plates 9 and 10. Dec., 1879.

A Subject-Index of the Publications of the U. S. Naval Observatory, 1845–75; by Edward S. Holden, Prof. Math. U. S. N. 74 pp. 4to. Washington, 1879.

Archives de Biologie, redigées par M. Ed. Van Beneden et Ch. Van Bambeke. 1st year, 1880. In quarterly numbers, making a volume annually of about 600 pages and 20 to 25 plates. Subscription price 30 francs, or for single numbers 9 francs. Paris: G. Masson, éditeur.

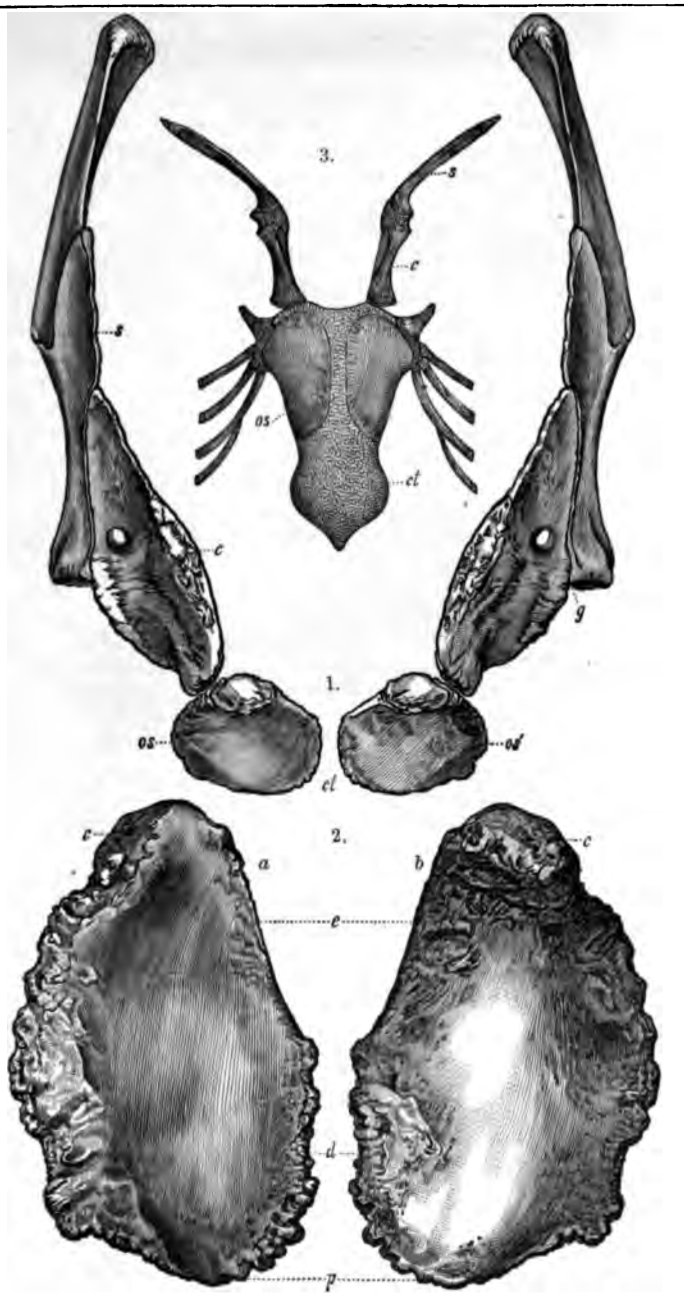


Figure 1.—Scapular arch of *Brontosaurus excelsus*, Marsh; front view, one-sixteenth natural size; *s.* scapula; *c.* coracoid; *g.* glenoid cavity; *os.* right sternal bone; *os'.* left sternal bone; *cl.* cartilage.

Figure 2.—Left sternal bone; one-eighth natural size; *a.* superior view; *b.* inferior view; *c.* face for coracoid; *d.* margin next to median line; *e.* inner front margin; *p.* posterior end.

Figure 3.—Scapular arch of young *Rhea Americana*, Lath.; (after Parker); *three-fourths* natural size; seen from below. Letters as above.

THE

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[THIRD SERIES.]

ART. LVII.—*On the Physical Structure and Hypsometry of the Catskill Mountain Region*; by ARNOLD GUYOT, Princeton, New Jersey.

IN a former paper on the physical structure of the Appalachian system, I noted the fact that, though extending through the most populated and civilized part of the United States, that system of mountains was still among the least known of our country. This remark applies with double force to the Catskill Mountain region.

Situated in the old and flourishing State of New York, only one hundred miles from its metropolis, in full sight and within a few miles of the great artery of travel, the Hudson River; visited every summer by thousands of tourists in search of the beauties of nature and of the cool air of its high valleys and plateaus, its real mountain region has been thus far almost a sealed book to the geographer and the geologist as well as to the transient visitor. It seems a matter of legitimate surprise that to this day no physical map of the Catskills, deserving the name, could be found. True, there are county and township maps which trace with tolerable accuracy the water courses, the roads, the villages and the scattered farms; but they all end with the cultivated portions of the valleys and leave the mountains either in blank or give them in very inaccurate and unintelligible outlines.

For one, however, who has visited that part of the country, with the view of studying its physical conformation, the cause of the sad condition of its cartography is no mystery. The whole region was originally an unbroken forest, and, with the

exception of the bottom and slopes of a few valleys and of some portions of the northeastern plateaus, it has remained so to this day.

The wilderness of the Adirondacks is more extensive but hardly more complete than that of the pathless forests of the Southern Catskills, the habitual haunts of numerous bears, wild cats and occasional panthers. Add to this the fact that most of the mountain tops, not to say all, are not sharp peaks, but extensive thickly wooded flats from which no distant views can be obtained and it may readily be understood what difficulties lie in the way of the topographer and why ordinary surveys stop short of the mountain chains.

And still several features of the Catskills are well calculated to excite in a high degree the curiosity of the scientific investigator, and to call for a thorough study of its plastic forms. Though situated in the midst of the Appalachian system, and evidently a part of it, it appears in it as an anomaly. While the Appalachian ranges, throughout the system, invariably trend from the southwest to the northeast, all the chains of the Catskills run in an opposite direction from the southeast and east to the northwest and west.

I have shown elsewhere in this Journal, the existence of transverse chains, in the Appalachians of North Carolina and Georgia, reaching 5000 and 6000 feet between the Blue Ridge and the Great Smoky Mountains. But these two great border-chains at least retain the normal direction, while, in the Catskills, even the border-chains run at right angles to the system. Again, while the neighboring Appalachian chains, the Kittatinny, or Blue Mountains, in New Jersey, hardly reach 1800 feet, and their continuation, the Shawangunk, rarely exceed 2000 feet (Sam's Point 2341), the group of the Catskills suddenly rises to double that height. On the east, beyond the valley of the Hudson, the Green Mountain ranges remain lower by 1000 and 1500 feet. On the north, beyond the deep valley of the Catskill Creek, the plateaus average less than 2000 feet and on the west the swells of land, around the sources of the Delaware and Susquehanna, do not much surpass that average, their highest points seldom reaching 2400 feet. The Catskills stand as a mighty citadel overtowering by 2000 feet all the surrounding country.

These apparent anomalies in the otherwise regular structure of the Appalachian system need an explanation. The first step toward it was to obtain a correct idea of the topography and orography of the region, and of the direction and altitude of its mountain chains and valleys, which no existing map could give. To this work the writer has devoted several summer vacations, from 1862 to 1879. The results of these observations are

mostly embodied in a map, now engraved* which is believed to furnish the first accurate delineation of these mountains. A few words on the manner in which these results have been obtained may not be amiss here.

The map, of which Plate XIX gives a reduced sketch, was drawn by my assistant, E. Sandoz, and engraved on the scale of one inch for three miles. It covers a surface of about 4000 English square miles, of which the mountainous part proper occupies somewhat more than one half, or about 2400 square miles. The position of all the mountain peaks was obtained by means of a theodolite and a sextant, both reading to a minute of a degree; the points of the triangulation of the Coast Survey along the Hudson River serving as a base.

From the nature of the case none but natural signals could be used; but the very large number of "tours d'horizon" observed from every prominent point, with profiles regulated by angular positions, render errors of any consequence extremely improbable. I was, therefore, hardly surprised, but much gratified, to find that the position of the only point the map has in common with the triangulation of the New York State Survey, the Utsayantha, near Stamford, though determined entirely independently, was in close accordance with that assigned to it by this carefully conducted survey.

The Hydrography was taken from the most recent county and township maps of Greene, Ulster, Delaware and Schoharie counties and has been regulated by the position of the mountains.

The altitudes have been measured by mercurial barometers with the aid of assistants, all trained by myself; in only a few of the less important points the aneroid was used to obtain a preliminary measurement. Among my most useful assistants I must mention E. Sandoz for all the Northern Catskills, Wm. Libbey, Jr., for observations and computations in the Southern Catskills, John Reid and Samuel E. Rusk for the eastern portions. Most of the aneroid observations I owe to H. Kimball, the most indefatigable and skillful mountain climber of the Catskills.

The formula used in the computations is, as in my other measurements, that of Laplace, in connection with a table of corrections for the influence of the hour of the day and the barometrical coefficient, which I have derived mainly from the elaborate reduction of the meteorological observations of Geneva and St. Bernard by Plantamour.

The altitude of five points, not more than ten miles apart, was determined with great care from the Hudson River and the Delaware and Ulster Railroad, and each served as a base for

* The map is for sale by Charles Scribner's Sons, and B. Westerman, New York City.

the measurement of the neighboring heights. They are "the Vista," at Haines' Falls, for the east, Molyneux's farm for the southern Catskills, Lexington Village and Windham Center for the central region and Vaughn's Highland House for the north and west. They have been tested by reciprocal observations among themselves. The altitudes are reduced to the mean tide level in New York harbor, assuming this to be about 2½ feet below mean tide in the Rondout and Catskill Creeks.

The name Catskills is said to have been given to this wilderness by the first settlers, who were of Dutch origin, on account of the numerous wild cats inhabiting its forests. To the same settlers are due the geographical appellations of *kill* for stream, *clove* for gorge, and *vly* or *vlaie* for swamp, so frequently met with in the Catskills. The boundaries of the region to which the name applies, however, are not well defined. But confining it between the Hudson River and the sources of the Delaware, from east to west, and the Catskill Creek and the sources of the Navesink and Rondout Creeks, from north to south, we enclose the mountain district which has the special characters above indicated; and this is the portion comprised in the new map. It must be said, however, that the inhabitants of the plateau region north of Catskill Creek, to the Helderberg Mountains and west to the sources of the Susquehanna, claim to be still in the Catskills.

The mountain region is divided by the Esopus Creek into two groups differing considerably in their physical structure, one on the north, the northern or Catskills proper, situated mainly in Greene county; the other on the south, the southern Catskills or Shandaken Mountains, in Ulster county.

The *Northern or Catskills proper*, between the Esopus and Catskill Creeks, form a massive plateau having the shape of an irregular parallelogram, extending from S.E. to N.W., and shut up between two high border chains, ten to fifteen miles distant from each other, running about in the same direction. The southwest border is formed by what may be called the central chain of all the Catskills, the other by the northeast border chain. The southeastern end is closed by the short chain of the High Peak; the northwestern by the high swell of plateaus which divide the headwaters of the Delaware and Susquehanna from those of the Schoharie Creek and the Hudson. Inside of this highland three secondary ranges, starting from the northeast border chain and running nearly west, almost to the foot of the central chain, fill the inner space, enclosing deep valleys in which flow the waters of the Schoharie Creek and its tributaries.

The only access to this interior highland is through the deep and wild gorges called cloves, of which there are but few; all

renowned for the picturesque beauty of their torrents and cascades, and for their ice caves.

A striking peculiarity of the plastic forms of the northern Catskill group is that while its western end is, as it were, buried in the general plateaus of western New York, its mountains rising but moderately above their surrounding base, its eastern end stands isolated on three sides by deep and broadly open valleys, projecting, in all its height, as a mighty promontory, to within ten miles of tide water in the Hudson River.

The very base of its mountains rarely exceeds 600 feet above tide. The altitude of Woodstock at the base of the Overlook Mountain is 594 feet; the entrance of the Plaaterkill Clove, at West Saugerties, 660 feet; the entrance of the Kaaterskill Clove, 600 feet; Kiskatom, near the foot of the North Mountain, 687; Acra, not far from the base of Blackhead, 546 feet; Cairo, 347 feet. No wonder that the aspect of the Catskills is no where more imposing than from the Hudson River and the surrounding lowlands, from which their whole height is seized at a glance, and that it has been thus far believed that the highest points were found among the mountains of the eastern end. It is thus that the Round Top of the old geographies, now called the High Peak, at the head-waters of the Schoharie Creek, retained for over half a century the undeserved reputation of being the culminating point of the Catskills. This deception was common even to the inhabitants of the interior, and nothing but actual measurement could convince them of their error.

The panorama of mountains, viewed from Catskill village, extending from the Overlook Mountain, on the south, through the High Peak, the North Mountain, Black Head and Windham High Peak, is not a single chain, but rather the eastern end of the border chains together with that of the short range bearing the High Peak, which rises between the two. It is, therefore, but the abrupt termination of the whole mass of the Highlands toward the great gap to the Hudson Valley, as a description of the orographic structure of the plateau will show.

To make this description clear, a few preliminary remarks on the general geological structure of the Catskills, and the characteristic features of their topography seem to be desirable. We have not to look in the chains of the Catskills for a series of anticlinal and synclinal folds or arches, or fragments of arches, as in ordinary mountain chains. Throughout the region the strata of which they are composed are nearly horizontal from the bottom of the valleys to their top, or have a dip rarely exceeding four or five degrees. The same is true of the plateaus.

The mountains, therefore, whatever be their external forms, as well as the surrounding plateaus, are masses of piled up strata, with a slight inclination to the south or southwest and northwest, often hardly perceptible. A greater disturbance from the horizontal position is seldom observed and, when found, is only local. To this disposition of the strata and their tendency to break by the joints at right angles to the planes of stratification we must trace the occurrence of those abrupt ledges which are so frequently encountered by the traveler, and are often a cause of serious difficulty and no little danger to the inexperienced mountain climber. This also explains why the tops of the mountains are not pointed peaks but mostly flat surfaces, often of considerable extent, and why it is only at the edges of these that are found the perpendicular ledges which border precipices of vertiginous depth and disclose the splendid views which have rendered the Catskill Mountain House and the Overlook Mountain so celebrated. To the same cause, again, and to the peculiar mode of disintegration of the strata by successive steps, are due the numerous cascades which are so characteristic of the Catskills, and one of their greatest attractions.

Most of the peaks measured were, as usual in American wildernesses, without names. I had to find some fitting appellations. Those in use, such as Roundtop and High Peak, North and South Mountains, are so often repeated in all parts of the Catskills that to prevent confusion it was sometimes necessary to change or to qualify them. In the new ones I tried to avoid the fanciful names so much in vogue, and to derive them when possible from their geographical location. To Roundtop at the head of Little Westkill I applied the old Indian name of the region, Ontiora. Roundtop at the head of Drybrook became Doubletop, a name which from its form is more appropriate; South Mountain close to it is called on the map Graham Mountain, in honor of its owner, one of the old settlers of that district. In the Catskills nearly all valleys and passes are called *hollows*.

The *Central Chain* is, as before mentioned, the longest, the most massive, and plays the part of a back bone for the whole Catskill region. It forms at the same time the southwestern border chain of the Northern Catskills. Its total length from the Overlook Mountain, its southern end, to the Utsyantha, near Stamford, its northwest termination, is somewhat over thirty-five miles. Its direction is not uniform: in the first half to the Deep Hollow gorge its trend is west-northwest; at that point it turns sharply to the northwest. It descends in long slopes and heavy spurs toward the south and west, while it falls abruptly toward the interior to the northeast.

The central chain is divided into four, almost equal, portions by three deep gorges or cloves which give access to the interior valleys; the Stony Clove, summit of road 1700 feet, reaching the Schoharie basin near Hunter village; the Deep Hollow, summit 1973 feet, near Westkill, and the Grand Gorge Railroad depot, 1570 feet, near Moresville.

1st. The first part, from the eastern end to the Stony Clove, is about ten miles in length. It begins with the Overlook Mountain, and turning north reaches the Plaaterkill Mountain with which it forms a horse shoe having its convexity to the east and enclosing to the west the valley of the Sawkill with Shue's, or Echo, lake at its head.

From the Plaaterkill Mountain it stretches 20° north of west to the Stony Clove, along the valley of the Plaaterkill and Schoharie Creek. The prominent points from east to west are the Indian Head, with three peaks increasing in height toward the west, followed by the two Schoharie peaks rising from one mass, the higher one on the northwest of the other; then comes the Mink Mountain, with a broad rounded shape and a prominent projection to the north; still beyond is the long, flat, table-like Stony Mountain which falls by precipitous ledges into the Stony Clove. The flat summit of the last is so regular that the measurements of six points along the ridge did not show a difference exceeding a score of feet. Except for the Overlook, I found no current names for these various well-defined mountain tops. Those which I here propose are mostly suggested by their position.

The Plaaterkill Mountain is at the south entrance of the Plaaterkill Clove. Indian Head was a name given to me by an old hunter of the locality. The Schoharie Peaks are at the head of Schoharie Creek. Mink Mountain borders the Mink Hollow of the old settlers; and Stony Mountain is next to Stony Clove.

The altitudes, as shown in the following table, increase regularly westward to Hunter Mountain.

TABLE.

Overlook Mountain,	3150	Schoharie Peak, N. W.,	3650
Plaaterkill "	3280	Mink Mountain,	3807
Indian Head, East peak,	3380	Stony Mountain, East end,	3844
" Middle peak,	3510	" Center,	3823
" West peak,	3581	" West,	3789
Schoharie Peak, S. E.,	3583	Hunter Mountain,	4038

Two passes cross this first part of the chain, the Indian Pass, from the head waters of the Schoharie and Plaaterkill, east of the Indian Head, to the Sawkill valley and the Overlook, the elevation of which is 2694 feet; and the Mink Hollow, between the Mink and Stony Mountains, with a wood road whose summit is 2629 feet. This last is said to be the trail by which the

first settlers gained an entrance into the interior of the Catskills; for, though being over 900 feet higher than Stony Clove, it is more easy of access than that wild and rocky gorge. Stony Mountain sends to the southwest a high, massy spur of considerable elevation, between the Stony Clove and the Beaverkill, where it bears the name of the Oleberg, or Olderbargh Mountain.

The Overlook Mountain, on the southeast, and the South Mountain, near the old Mountain House, on the northeast, are two great promontories of the Northern Catskills, both terminating in perpendicular ledges; two natural observatories, from which the most extensive views are obtained over the broad valley of the Hudson, the chains of the Highlands and the Green Mountains. The Overlook can boast besides of a fine panoramic view of the high chains of the Southern Catskills.

The second portion of the central chain, between the Stony Clove and Deep Hollow, a distance of 10 miles, is composed of two chains and contains the culminating points of the whole. It begins, on the east, by the broad mass of the Hunter Mountain, the highest point of the Northern Catskills, 4088 feet. This sends to the north a long and rocky spur terminating opposite Hunter village in the precipitous and rocky ridge bearing the name of the Colonel's Chair, 3087 feet. It expands similarly to the southwest into a broad ridge. To this is attached the Westkill chain, which, from its direction and greater altitude, may be considered as the true continuation of the central chain; while the Lexington chain attached to the northern spur is but a secondary feature. Between these two chains lies the deep valley of the Westkill, nine miles long, with the abrupt sides of the mountains turned toward it. The Westkill chain, like the Stony Mountain, descends toward the southwest in long and gradual slopes which look more like an inclined plateau deeply furrowed by a few narrow valleys, such as the Peck Bushkill valley, the Broadstreet and Forest valley, the Ox Clove; all tributaries of the Esopus. This, in truth, is the outer margin of the north Catskill plateau. The Lexington chain, between the Westkill and Schoharie Creeks, falls abruptly on both sides.

The altitudes of both ranges decline regularly from Hunter Mountain westward, but more rapidly in the Lexington chain, which terminates rather suddenly in the Lexington Flats; while the Westkill chain retains its preëminence and continues the main chain. In the last the Big Westkill rises to 3896 feet and at the west end the Deep Hollow Mountain still measures 3500; while in the Lexington range Rusk Mountain is only 3626 and Lexington Mountain, at the west end, 2930 feet. The gaps in these two chains are indentations

without depth. Jones' Gap, between Hunter and Rusk Mountains, is the only one through which a wagon road passes. The Broadstreet Gap, in the middle of the Westkill chain, has hardly more than a mountain trail. The Hollow Tree Gap, near Hunter Mountain, and Peck's Gap, in the western half, are even less accessible. All this district between the Stony Clove and Deep Hollow gorge, the Esopus and Schoharie Creek, is still one of the wildest and least known of the Catskills.

The third part of the central chain, between the Deep Hollow and Grand Gorge, is the longest—11 miles—but its elevation gradually diminishes. Its general direction changes abruptly, at the Deep Gorge, from west 10° north to north 30° west. It begins on the east by the Beech Ridge with a slightly undulating top reaching in the Vlaie Mountain 3531 feet; is depressed in the Halcott Gap to 2725 feet, beyond which it rises again to the height of 3545 feet in the Bear Pen. It somewhat declines in Pond Mountain and the Ontiora, or Roundtop, at the head of the little Westkill, 3458 feet, and terminates by Jones Mountain, hardly lower than Ontiora, and the Irish Mountain near Grand Gorge.

Ontiora deserves a special mention for the great beauty and extent of the view it affords from its summit.

It is one of the two or three mountain tops which are free from trees. From this high observatory the eye takes in at one glance almost the totality of the Catskills including the Slide Mountain on the extreme south; High Peak and Black Head, on the east; Windham High Peak, Pisgah and Ashland Pinnacle, on the northeast; Utsyantha, on the northwest; and the innumerable hills of Delaware county, on the west and south. It has besides the merit of being easy of access by a well graded road from Prattsville and Batavia Kill, passing within half a mile of its summit at an elevation of 3180 feet.

This portion of the central chain unlike the preceding one has, on its southwestern slope, long and broad valleys—the Halcott Bushkill, Batavia Kill and Roxbury—whose waters form the east branch of the Delaware; and between which are ridges, sometimes full as high (such as the Red Kill Mountain 3540 feet) as the main chain with which they are connected.

The northeastern, or interior, slope is much less abrupt than in the Westkill chains. The only indentation of importance is the valley of the little Westkill.

The fourth and last division of the central chain, from Grand Gorge to Utsyantha, six miles, begins with the Bald Mountain near the Grand Gorge Depot of the Ulster & Delaware Railroad, continues by the slightly higher chain of the Moresville Mountains and, beyond a gap of moderate depression, terminates suddenly in the Utsyantha Mountain, near Stamford, with

an altitude of 3208 feet. This is also nearly the height of the Moresville range.

Utsyantha, at the head of the West branch of the Delaware, may be considered as the end of the Catskills in this direction; beyond it all high mountains disappear and the chains lose themselves in plateaus which increase in height on all sides. The following table shows the regular decline from Hunter Mountain to the end of the chain.

TABLE.

Hunter Mountain,	**4038**	**Utsyantha,**	**3208**
Big Westkill,	**3896**	***Lexington Range.***	
Deep Hollow Mountain,	**3500**	**Rusk Mountain,**	**3626**
Vlaie Mountain,	**3531**	**Beeline Mountain,**	**3300**
Bear Pen,	**3545**	**Pine Island Mountain,**	**3086**
Ontiora,	**3458**	**Lexington Mountain,**	**2936**

From the foregoing description it will be seen that, if we connect the mountain tops along the central chain by an ideal plane, it will gradually rise from the east end one-quarter of the distance to Hunter Mountain and thence descends still more gradually to the northwest end, no local peaks interrupting its normal slopes. The two ends, the Overlook Mountain, 3150 feet, and Utsyantha 3205 feet, are nearly equal in altitude.

Hunter Mountain is by far the most remarkable in the whole range. It is owing to its broad massive form, with no well defined peak rising from its uniform summit, that its superior height was not discovered nor even suspected by the inhabitants of the valley, while the High Peak looming up, isolated and in full view from the Hudson, gained a reputation for preëminence though, in fact, nearly 400 feet lower.

2d. *High Peak Range.*—High Peak, or the old Roundtop, so long celebrated as the culminating point of the Catskills, is the highest part of a short range running between the two head branches of the Schoharie Creek, parallel with the central chain and connecting it with the northeast border chain. Its mass fills all the space between the Plaaterkill and Kaaterskill Cloves, in the depths of which it falls in precipitous slopes, adorned by leaping cascades. On the east it descends more gently in terraces toward the plain. Its summit is capped, as many others in the Catskills, by thick layers of a hard conglomerate, which, having better resisted the destructive agencies of the atmosphere, stand distinct as a round head nearly 800 feet high, on the broad shoulders of the mountain, and suggested its first name, which ought to have been retained. The direction of this range is west 30° north: its length only six miles. High Peak, its eastern end, rises to 3664 feet; a second peak, hardly a mile distant to the west, now called Roundtop, is still 3500 feet; but farther on the chain descends rapidly, termina-

ting in Clum Hill, 2372 feet, near the confluence of the two branches of the Schoharie Creek.

From its central position this last hill affords a most instructive panorama of the interior chains.

3d. The northeast border chain appears more like the outer wall of the Highlands, falling from the top of the mountains to the valley of the Catskill Creek. Though its general direction is to the northwest, the individual parts show a succession of alternate north and northwest trends.

From the South Mountain, near the Catskill Mountain House, to the North Mountain the direction is north; from North Mountain to Black Head, northwest; from Black Head to Acra Point, north; from Acra Point to Windham High Peak, west 30° north; from the last point to East Windham Gap, northwest; from the Gap along Mt. Zoath, due west; from Zoath, through Mt. Hayden, Pisgah and the northwest terminal chain, northwest again.

The altitudes along that chain follow the same order as in the central chain opposite, but are somewhat lower. South Mountain at the Star Rock, near the Coast Survey Signal, is 2497 feet; North Mountain, east end, 3285 feet, and its highest point 3442; Black Head, the highest of the range, 3945; Acra Point approximates to 3085 feet; Windham High Peak, 3534; Mt. Hayden, 2900; Pisgah, 2905; in the terminal range Sutton Hill, 2573 feet; High Knob, 2654; Barlow Hill, 2651 feet; Leonard Hill, 2649 feet.

Here again, as in the central chain, a general plane carried through the summits would show a comparatively rapid rise to Black Head, one quarter of the distance, and a much more gradual descent from Black Head to its termination. As in the central chain the two ends, east and west, the South Mountain, 2497 feet, and Leonard Hill, 2649 feet, have about the same altitude. It would be still more alike if instead of the Star Rock, on the border of the ledges, we took the real culminating point of South Mountain, a short distance farther west.

The general slopes of the border chain toward the valley of the Catskill Creek are steep, rarely less than 25° to 28°; but reaching the foot of the mountains, they change quickly to gentle undulations descending by a slope of 6° to 8° to the Catskill Creek, making the valley very broad and open. In the interior the slopes are equally steep, but much shorter, as the bottoms of the valleys are 2000 feet and over above the sea-level. The passes which afford an entrance into the interior valleys are about as high as in the central chain. In Pine Orchard, the Catskill Mountain House lies 2225 feet above tide; the Summit House, in East Windham Notch, 1940 feet

in the northwest terminal chain, Sutton Gap, 2236 feet; Potter's Hollow Gap, 1966 feet; Bennet's Notch, 1997 feet.

4th. The highland between these two main chains has, as remarked before, the shape of an irregular parallelogram. Its length is about twenty-seven miles; its width, between the Plaaterkill and South Mountain, only six miles. It increases to ten miles between Stony Mountain and Black Head, reaches its maximum—fifteen miles—between Deep Hollow and Pisgah, and is reduced to 12½ miles between Grand Gorge and High Knob. The central part is filled by three ranges, separated by valleys in which flow the tributaries of the Schoharie Creek: 1st. The Eastkill and East Jewett Range starting from the North Mountain and running a few degrees north of west, 12½ miles long; 2d. The Black Head Range, from Black Head due west, continued by the West Jewett Range, sixteen miles long; 3d. The Pisgah Range running west 10° south, a distance of ten miles.

The Eastkill and East Jewett Range, between the main Schoharie Creek and the Eastkill, is divided into two parts by the Parker Notch, 2415 feet. The first detaches itself from the North Mountain, 3442 feet, and descends rapidly to the Star Rock of Parker Hill, 2545 feet. The second to the west rises again to 3190 in the Eastkill Mountain, and 3146 in East Jewett Mountain; both north of Hunter village, on either side of a deep notch.

The Black Head Range runs from Black Head nearly due west for five miles, gradually descending to the Big Hollow Gap road. Its great height, its massive forms, its fine rounded summits, whose aspects vary from every new point of view, make it the most conspicuous of these inner chains and a prominent feature of the landscape. The central part, the long and symmetrically shaped Black Dome, attains the height of 4003 feet. It is cut off from its neighbor Black Head with its steep and rocky slopes, by the Lockwood Gap, 3446 feet; while the following peaks to the west: Mt. Kimball, 3960; No. 4, 3566, and No. 5, as yet nameless, are only separated by slight depressions.

Between the Big Hollow and Henson Gap roads, 1800 feet, rise two rounded hills, 2500 feet high, cultivated to the top, and from which one of the most varied and extensive panoramic views of the Catskills may be obtained. On the same line, farther west, the Jewett Range has an altitude of 3025 feet, at its culminating point, just above Windham Center; and of 2931 feet in the conical Tower Mountain, above Ashland. This Black Head Range, with its continuation, separates the valleys of the Eastkill and Bataviakill, the two main tributaries of the Schoharie Creek.

The third and most northern of these transverse chains begins at Mt. Pisgah, 2905 feet, and stretches west 10° south for about ten miles between the Bataviakill and the Manorkill. Unlike the others it grows in altitude westward. Next to Pisgah the wooded summit of Richmond Peak is 3202 feet high; Strawberry Knob, 2975, and Sister Mountain, 3002 feet; while Ashland Pinnacle, with its 3420 feet of elevation, rivals the high peaks of the central and border chains. The two slopes are very unequal. On the south they descend gently, almost plateau-like, for five or six miles to the Batavia-kill; on the north they fall rapidly to the Manorkill Valley, reaching the same level within a mile from the ridge.

Beyond the Manorkill, both on the east and west side of the deep Schoharie Valley, the high mountain chains disappear. Plateaus from 1500 to 2000 feet of elevation become the prominent feature. The series of hills, of 2650 feet, forming the northwest end of the border chain, hardly rise more than 500 or 600 feet above their apparent base, and soon lose themselves in the surrounding plateaus, before reaching the valley of the Schoharie.

On the west side of the valley a long and high swell of land, starting from the Utsyantha, near Stamford, stretches directly to the north, dividing the waters of the Schoharie from the head waters of the Delaware and Susquehanna, and joining the plateaus which border the Mohawk River. North of Stamford this table land bears a group of hills, among which Mine Hill, the highest, measures over 2800 feet. Wood Chuck and Potter Mountains are but little lower. Farther north the plateaus culminate in Summit at the height of about 2400 feet.

Drainage.—A glance at the map will teach still better than any description that the interior highlands of the Catskills proper are drained, from beginning to end, alone by the Schoharie Creek and its tributaries. They thus form a unique hydrographic basin.

It is true that the Kaaterskill derives the main part of its waters from the inner amphitheatre formed by the South Mountain, the ridge on which stands the Mountain House, and the North Mountain Outlook, at the bottom of which they collect in the Catskill Lakes; but this can scarcely be regarded as an exception; for after a course of not much more than a mile they suddenly leap into the deep gorge forming the beautiful cascade of the Kaaterskill and joining the other branch which descends from Haines' Falls, their rivals in wild beauty, they hurry together in rapids through precipitous chasms out of the mountains. The whole distance from Haines' Falls, at the head of the valley to its outlet, at Palenville, is only three miles. The same may be said of the Plaaterkill Creek, which flowing from

the Indian Head precipitates itself almost immediately into the deep clove bearing its name, from which its roaring waters issue only two miles below. Both properly belong to the outside slopes.

The main Schoharie Creek originates at the foot of the Schoharie peaks, near the head of the Plaaterkill Clove, from which it is hardly separated by a slight swell in the swampy valley bottom. It follows closely the foot of the central chain and receives just below Tannersville its first affluent, also coming from swampy meadows near Haines' Falls, at the head of the Kaaterskill Clove; these two head streams embracing the chain of the High Peak. The creek, keeping the direction of the central chain to the west-northwest, flows through Hunter village 1609 feet to Lexington, 1320 feet, where it turns with the chain to the northwest, to the mouth of the Beaverkill Creek, beyond Prattsville, 1164 feet.

Here it leaves the central chain and, running almost due north to the confluent of the Manorkill, it enters the mass of the northwestern plateaus, cutting from Gilboa 1088 feet, to Middleburg 640 feet, a deep and narrow valley, the bottom of which is from 1000 to 1800 feet below the general level of the country it traverses, while the occasional flat bottoms in it at Blenheim, Breakabeen, Fultonham and Middleburg, rarely attain more than half a mile in width. Its course from Blenheim, through Middleburg, Schoharie and Central Bridge, where it receives the Cobbleskill Creek, is alternately to north-northeast and north. From this place, instead of following the broad valley through which runs the Albany and Susquehanna Railroad, it leaves it and cutting its way at right angles through the high hills which border the Mohawk, it finally enters that river near Fort Hunter, after a course of over seventy-six miles.

All the main tributaries of the Schoharie Creek in the mountain region, the Eastkill, the Bataviakill, the Manorkill, come from the northeast border chain and flow almost due west toward the central chain, on the opposite side, where they enter the main creek; the Eastkill, three miles above Lexington, the Bataviakill just above Prattsville, the Manorkill at Gilboa. Like most valleys of erosion they offer, in their upper and middle course, a succession of flat and open basins from which they fall through narrows, in rapids and cascades, into the valley of the main creek. The left affluents from the central chain, the Westkill, Little Westkill and the Beaverkill, are all inconsiderable in length and volume. In the region of the plateaus another Westkill, on the west, at Blenheim, and the Keyserskill on the east, at Breakabeen, are hardly more than mere torrents.

The contrast of the broad open valleys between the mountain chains above described, and the narrow and deep cut of the Schoharie Creek when passing through the plateau region is a feature to be noted.

This drainage which sends the waters of the Catskills all the way around to the Mohawk to come back by the Hudson, after a course of 175 miles, to within 10 miles of their starting point is certainly remarkable, and betokens a very peculiar physical structure. This is made more striking by the fact that on both sides of these highlands the waters of the valleys of the Catskill and Esopus Creeks flow, as we might have expected, from the western plateaus directly to the Hudson River. These three streams, which are so near each other, flow in opposite directions, and it seems as if this plateau of the Catskills had been lifted up on its eastern part to a higher level from which its waters were sent in the opposite direction.

From the nearly horizontal position of the strata which is common to the mountains and the surrounding plateaus and from the peculiar features of the drainage, we are led to admit that the plastic forms of the Catskill region are the work of the erosive forces which have been so long active since the time of their first upheaval. Neither of these mountain chains, the central no more than the transverse ranges, have the character of anticlinal axes of elevation, nor are the valleys synclinal folds. These orographic features therefore are not due to the ordinary dynamic process which has folded and shaped into southwest and northeast mountain ranges, the other portions of the Appalachian system, and do not constitute an exception to the rule. The idea of a series of axes of elevation, the principal of which is prolonged on the northwest to Little Falls, on the Mohawk, and is often represented as connecting the Catskills with the southern chains of the Adirondacks, has thus no foundation whatever in nature. The nearly continuous heights, up to 2000 feet and more, which form the water-shed between the Schoharie Creek, the Mohawk and the various branches of the Susquehanna are but the swelled border of the plateaus falling rather abruptly into the Mohawk valley. We may, therefore, conceive the original form of the Catskills to have been that of a high plateau, a mass elevation, forming a part of the Appalachian plateau region which extends west of the Alleghanies from South Virginia, and fills nearly all the western portion of the State of New York, south of Lake Ontario and the Mohawk River. The lowest altitude of the primitive plateau is marked by the ideal plane which would pass through the mountain tops, and its superior elevation on the east would account for the flow of the waters, the gradual scooping out and the sloping of the valleys in the direction

they now have. This may also explain the possibility of the creek, below Prattsville, cutting through the western plateau a thousand feet higher than its level, when we conceive that the erosion was begun by a stream coming from a higher level than the present plateau.

The Southern Catskills are far from having the regular features which characterize the Northern group; nor are the boundaries as well defined, except along the Esopus valley. The central mass containing the most continuous and elevated chains, from which flow the head waters of the Esopus on the north and of Navesink and Rondout Creeks on the south, occupies the townships of Shandaken and Denning. It is flanked on the east by several high chains running north and south, in Olive, and on the west by long ridges, extending to the southwest and northwest into the Delaware Basin, in Hardenburg. The extent of this mountain tract from the Esopus at Olive City to the Delaware near Margaretville, at the end of the Drybrook ridge, is 25 miles; its width from the Esopus at Shandaken to the southwestern boundary of Denning is about 16 miles.

We find here no interior plateau enclosed between high border chains. The massive central chain, which bears the highest summit is accessible from all the surrounding valleys without crossing any high pass; but the roughness of the wild mountain torrents and the unbroken primitive forest make that access anything but an easy task. Though the direction of the main chain is about the same as in the northern Catskills, viz: west-northwest and northwest, several important ridges run to the north and northeast, almost at right angles, a direction never found in the first group, and imparting considerable irregularity to the physical structure of the Southern Catskills.

The main chain, beginning with the Slide Mountain, stretches west 22° north for 8 miles to the broad knob of Eagle Mountain, from which it turns at right angles, north 30° east, 4 miles to Balsam Mountain, and changes again, beyond the Lost Cove, to north 40° west in Belle Ayre where it terminates. The first two parts form a dark, high, unbroken wall of 12 miles, densely wooded, crossed by a single wood road, in the Big Indian, or Helsinger Notch, 2677 feet. Few summits rise much higher than the general crest. They are, from east to west, the Slide Mountain 4205 feet, Hemlock Mountain, Spruce top 3567 feet, Fir Mountain, about the same height, Eagle Mountain 3560 feet, Balsam Mountain, south end, 3601 feet. Belle Ayre has a milder aspect and descends to 3394 feet in its highest portion.

The Slide Mountain, the culminating point of the Southern, and the highest of all the Catskills, is in many respects quite remarkable. It terminates abruptly on the northeast toward the deep valley of Woodland, or Snyder Hollow, showing signs

of a slide of fallen rocks which suggested its name. From its broad triangular top it sends a ridge toward the southeast, which divides the waters of the Esopus from those of the Rondout, and terminates in the Lone Mountain 3670 feet, by which it is almost connected with the Wittemberg chain. Another high ridge descends toward the south and nearly reaches the high group of Table Mountain 3865 feet, and Peak-o'-Mouse 3875 feet, which separates the head waters of the Rondout from those of the East branch of the Navesink. It thus becomes the main hydrographic center of the region, sending its waters to the northwest by the Esopus; northeast to the same by the Woodland Creek; south by the Rondout to the Hudson; southwest by the Navesink to the Delaware. At 500 feet from the top, steep ledges, suddenly breaking the evenness of the ridge, mark the base of the cap of hard Subcarboniferous conglomerate (No. 10 of the 1st Pennsylvania Survey, according to James Hall) which crowns the king of the Catskills. An easy ascent is found by taking the road from Big Indian to the Helsinger Notch, from which the ridge, just beyond the Navesink waters, leads to the top by a regular and gentle slope.

On the east several chains not yet well studied run from the neighborhood of the Slide between the Woodland Creek and the middle course of the Esopus. The most important is the rough chain of the Wittembergs. The highest points are from south to north, Cornell Mountain, 3681, near Lone Mountain and on the line of the Slide; Friday Mountain and Great Wittemberg 3778 feet. Further to the east, and south of Shokan, High Point, celebrated for the beauty of its panorama, rises almost isolated from a low ridge to the altitude of 3098 feet.

Between the Slide and Balsam range, on the south and west, and the Wittemberg chain, on the east, lies the central plateau of the Pantherkill, 7 miles wide each way, wild and wooded, entirely surrounded by the waters of the Esopus and the Woodland Creek. It is surmounted by a long ridge running nearly due north from Slide Mountain with two prominent peaks, the highest of which, the Pantherkill Mountain, rises to an altitude of 3828 feet. It is deeply scooped out by torrents which pour their waters, on the west directly, and on the east by the Woodland Creek, into the Esopus.

On the southwest of the angle formed by the Fir and Eagle Mountains, but hardly connected with the main chain, rise two mountain peaks of still greater altitude, Graham Mountain, 3886 feet, and Double Top, 3875 feet, called respectively, by the few settlers South Mountain and Round Top. I have already said that my reason for changing these names was to avoid the confusion arising from their frequent repetition. These two high peaks, closely connected together, are situated,

in regard to the main chain, as Table Mountain and Peak-o'-Mouse are at the east end, south of the Slide; and both groups are of the same elevation. The Graham Mountain group is a remarkable hydrographic center sending many branches to the Delaware; the Drybrook and the Millbrook to the north and west; the Beaverkill and Navesink west branch to the south-west and south. Graham Mountain is also the head of a long ridge in which reappears the normal trend of the Appalachian chains, which is also indicated by the course of the Navesink and of the upper Rondout Creek. But all that region lies beyond the pale of my observations and requires further investigation.

What was said above of the Geological structure of the Northern Catskills is true of the Southern group.

Notwithstanding the greater variety of its plastic forms, which would, at first sight, indicate considerable dislocations, the nearly horizontal position of the strata, which predominates except in a few and limited localities, forbids the belief that they were the ruling element in their formation. The mountain chains are no anticlinals, nor are the valleys synclinals. Erosion and slow disintegration seem to have been the main efficient causes of the conformation of the surface.

If we reconstruct in imagination the original plateau from which these orographic features have been sculptured, by passing a plane through the principal heights, we shall find a law very much like that observed in the Northern Catskills. From High Point, at the eastern border of mountain land, 3098 feet, the plane passing through Lone Mountain, 3670, reaches in the Slide its maximum, 4200 at 7 miles, one third of its total length. It thence descends more gradually through the Eagle Mountain, 3500 feet, down to Belle Ayre, 3400 feet, 14 miles, or two-thirds of the entire distance.

Why it is that, notwithstanding the similarity of general structure, the streams in the Southern Catskills should have taken an opposite course and shaped themselves into an entirely different system, is not easy to say. The absence of border chains and of the eastern projection, so characteristic of the northern group, may partially account for this difference.

Primitive, and perhaps later, dislocations, even when in the shape of simple cracks, may have had a share of influence in bringing about the result. Traces of the great diluvian glaciers are found in abundance throughout the Catskills; but I have seen, in Switzerland, too much of the action of glaciers on the ground over which they move, to attribute to that latest of geological agencies any great influence on the fundamental features of the present topography of the mountains.

I am fully aware that to solve such problems and answer the

geological questions raised by the topographical features, indicated in this paper, requires a careful and exhaustive stratigraphical study which it was impossible for me to undertake while the arduous topographical and hypsometrical work demanded all my time and attention. This must remain for future investigation. Meanwhile, however, I will add here a few preliminary suggestions.

The masses of rocks forming the Catskill Mountains were deposited in a gulf of the Devonian Sea comprised between the Adirondack plateau and the Green Mountain range, including the low Silurian ridges between the Hudson and the foot of the Catskills, all of which were probably emerged when the Devonian age began. Most of New England was also above the level of the ocean. The thickness of the sediments shows that the bottom of this gulf gradually subsided during that time to a depth of some 5000 feet, constantly making room for new deposits.

The presence of the gray conglomerate capping the highest hills proves that the deposition of these sediments continued into the Subcarboniferous period, after which they were upheaved above the level of the ocean, before the deposit of the Coal-measures, and have remained emerged ever since.

The slight southward dip indicates that during the Devonian age a general and gradual rise of the continent took place from the north, which raised successively above water parts of the Lower and Upper Silurian, in the Helderberg and Oriskany sandstone, which were laid dry when the Catskill sandstones and shales were still depositing.

The most notable upheaval of the Catskill region probably took place at the time of the great revolution which raised the main Appalachian system; doubled the size of the early continent and closed the Carboniferous age. But the peculiar situation which sheltered it from the immediate effect of the force which was in play, the lateral pressure arising from the sinking of the bed of the Atlantic, modified the hypsometric form of that portion of the western plateaus.

A glance at the sketch (Plate XIX) will show that, when this great Appalachian upheaval began, the domain of the Catskills was secluded from the ocean by large tracts of preëxisting lands; the Adirondack plateau on the north, New England and the Green Mountain ranges on the east which, though affected themselves in a measure, served as a barrier against a strong action of the upheaving force from those quarters on the region beyond. Farther south, however, no obstacle intervening, the force was free to display its full power; and to this cause, I am inclined to attribute not only the folding of the numerous Appalachian chains, but also the remarkable

bend westward of the whole system, in Pennsylvania, as well as the significant fact that it is in the prolongation of the axis of that convexity that the western plateaus beyond swell to their greatest average height, in the region of the sources of the Susquehanna, Alleghany and Genesee Rivers. To this pushing northwest and northward of the land, and its reflex action northeastward, the swelling of the plateaus of western New York may be, in great measure, attributed. The Catskills would thus have been subjected to a pushing action, from three or four opposite directions, by the rising lands: From the Adirondack plateau on the north, from the Green Mountains on the east and from the rising Appalachians on the southwest and south; and hence, perhaps, their superior elevation above all the surrounding lands.

On the other hand, it might be supposed that the covering of the hard Subcarboniferous conglomerate, which must have been general in the Catskills, protecting the underlying strata of the Catskill formation against denudation, prevented their being swept away, as in the surrounding region, and thus preserved, in a greater measure, their primitive elevation. But the known facts hardly warrant more than a surmise.

In a very interesting paper published in the Proceedings of the American Association for the Advancement of Science, in 1875, James Hall announces, as the result of four years' observation of two of his assistants, the existence in the Catskills of four lines of anticlinals, nearly parallel to each other and running from the southwest to northeast in conformity with the ordinary trend of the Appalachian ranges; the synclinals occupying the summits, the anticlinals the bottom of the valleys. As the map and sections accompanying the paper have not been published, I cannot locate them, but one of the synclinals passes through the Slide Mountain. Notwithstanding the great difficulty of determining such stratigraphical changes in so rough a country when the dip varies but a few degrees, I am quite disposed to acknowledge the reality of a fact observed with so much care. But if the trend of these axes is what it is said to be, far from coinciding with the chains and valleys, they cross them almost at right angles, and were probably posterior to the scooping out of the valleys and mountain chains, on the conformation of which they had so little effect. They were the last effort of the forces which have shaped the main Appalachians.

A hypsometric feature which may refer to this order of facts is that the three maxima of altitudes, above 4000 feet, the Slide Mountain, Hunter Mountain and Black Dome, are situated in a straight line, trending from southwest to northeast.

The short descending plane from this line eastward, which

e have noticed as belonging both to the northern and the uthern group, may be due to a subsequent subsidence of the reat Hudson Valley.

This valley during the Champlain Epoch of the Quarternary ;e was an arm of the sea. The east end of the Catskills was en a series of high marine bluffs, worn out by the action of e waves, which would explain the abruptness of their eastern rmination.

I need not repeat that I consider the above suggestions as ere hints for future investigation.

I here add a classified list of most of the points mentioned, duced to the ground above mean tide level in New York ırbor. *B.* means a measurement by mercurial barometer, *ner.* by aneroid, *P.L.* by pocket level.

NORTHERN CATSKILLS.	Feet.
Half-way House	286
Palenville—Union Church	470
Entr. of Kaaterskill Clove	609
Palenville Hotel, lower bdg.	680
Morefalls bridge	883
Lakecreek bridge	1217
Haines' Falls, Chas. Haines	1890
Vista, Aaron Haines' Porch	1932
Bridge, Miles Haines	1906
Dixon's Hill	2045
Kiskatom	687
Sleepy Hollow	1290
Catskill Mountain House	2225
Catskill Lakes	2140
Laurel House Piazza	2038
W. Saugerties, Quarrybank	660
Head of Plaaterkill Falls	1855

Schoharie Creek—Main Valley.	
Headwaters Schoharie Cr'k	1900
Mulford's Summit House	2043
Tannersville Hotel	1926
Hunter Village, Rusk's	1609
Lexington Bridge	1320
Westkill Village	1538
Prattsville Hotel	1164
Gilboa Hotel	1036
North Blenheim, Bridge	800
Breakabeen, Creek	743
Fultonham, Church	714
Middleburg R. R. Depot	640

	Schoharie Creek—Tributaries.	Feet.
B.	Peters Farm. East Kill.	2100
B.	Jewett Heights, Church	1810
	Valley of Batavia Kill.	
B.	Big hollow, Church	1758
B.	Hensonville, Cross road	1646
B.	Union Society, Bloodgood	1670
B.	Windham Center, Hotel	1510
B.	Asland Center P. O.	1435
B.	Redfalls P. O.	1270
	Valley of Catskill Creek.	
B.	Cairo	346
B.	Acra	546
B.	Cornwallville	950
B.	South Durham	969
B.	West Durham	1884
B.	Durham Center	850
B.	Oakhill Bdg., Catskill Creek	609
B.	Cooksburg	756
B.	Preston Hollow	870
B.	Livingstonville	1100
B.	Franklinton	1260
B.	Potter's Hollow	870
B.	Smithton	1268
B.	Highland House, Piazza	1857
B.	Broome Center, Hotel	1973
B.	Makee's Corners	1964
	Central Chain.	
B.	Woodstock, Hotel	594
B.	Mead's House	1789

		Feet.
B.	Overlook Mountain House	2978
B.	Overlook Mountain	3150
B.	Plaaterkill Mt.	3280
B.	Indian Pass	2694
B.	Indianhead, East Peak	3380
B.	" Middle "	3510
B.	" West "	3581
B.	Schoharie East Peak	3583
B.	" West "	3650
B.	Mink Mountain	3807
B.	Mink Hollow, summit road	2629
B.	Stony Mt. East end,	3844
B.	" " Center	3823
B.	" " West end	3789
B.	Stony Clove, approximate	1700
B.	Hunter Mountain	4038
B.	Colonel's Chair, N. end	3037
B.	" " Highest	3165

Lexington Range.

B.	Rusk Mt.	3626
Aner.	Evergreen Mt.,	3624
Aner.	Bee line "	3300
Aner.	Pine Island "	3086
Aner.	Lexington "	2930

Westkill Range.

B.	Big Westkill Mt.	3896
PL.	Deep Hollow Mt.	3500
B.	Deep Hollow, Summit road	1973
B.	Beech Ridge Gap	3096
B.	Vlaie, or Fly Mt.	3531
	Halcott Gap, Sum. Road	2725
Aner.	Bearpen Mt.	3545
	Summit road to Batavia K.	3180
B.	Ontiora, Little West Kill	3458
B.	Utsyantha Mt. near Stamf.	3203

Chain of Highpeak.

B.	Highpeak (Old Roundtop)	3664
B.	Roundtop	3500
B.	Clum Hill	2372

North Border Chain.

B.	South Mt., near Mt. House	2497
B.	Palenville Overlook	1660
B.	Sunset Rock	2115
B.	Point of Rocks	2178
B.	North Mountain, Outlook	3100
B.	" " East Peak	3285

		Feet.
B.	North Mountain, W., Slope	[illegible]
B.	Blackhead	[illegible]
PL.	Burnt Mt.	[illegible]
B.	Windham Highpeak	[illegible]
B.	Grand View Hotel	[illegible]
B.	Cade Mountain	[illegible]
B.	Summit House	[illegible]
P.L.	Hayden Mt.	[illegible]
B.	Pisgah	[illegible]

East Jewett Range.

B.	Parkerhill, Star Rock	[illegible]
B.	Parker Notch	[illegible]
P.L.	East Kill Mt.	[illegible]
B.	East Jewett Mt.	[illegible]

Blackhead Range.

B.	Blackhead	[illegible]
B.	Lockwood Gap	[illegible]
B.	Black Dome	[illegible]
B.	Kimball Mt.	[illegible]
B.	Westpeak, No. 4	[illegible]
Aner.	Delong Mt.	[illegible]
Aner.	Hensen Gap, Summit road	[illegible]
Aner.	West Jewett Mt.	[illegible]
B.	Tower Mt.	2931

Pisgah Range.

B.	Pisgah	2905
B.	Richmond Cone	3202
B.	Sister Knob	3002
B.	Ashland Pinnacle	3420

Northwestern Catskills.

B.	Sutton Gap, road	2235
B.	Sutton Hill	2573
B.	Potter's Hollow Gap, road	1964
B.	Koni or Pine hill	2337
B.	Bennet Notch	1994
B.	High Knob	2654
B.	Best Hill	2649
B.	Barlow Hill	2651
B.	Gordon Gap, road	2504
B.	Gordon Hill	2629
B.	Leonard Hill	2649
B.	Manorkill	1520
B.	Stone Bridge	1382
B.	Strykersville	1215
B.	Platt Creek Church	1683
Aner.	Mine Hill	2810

SOUTHERN CATSKILLS.	Feet.			Feet.
Highpoint	3098	B.	Balsam Mt., South End	3601
Peak o' Moose	3875	B.	" " North End	3571
Table Mountain	3865	B.	Belle Ayre Mt., max	3394
Dominie Hammond's House	1945	B.	Graham Mt.—Dry Brook	3886
Lone Mt.	3670	B.	Doubletop	3875
Cornell Mt.	3681	B.	Segar's house—Dry Brook	1923
Wittemberg Mt.	3778	B.	Molyneux House Porch	1315
Woodland, N.W. Beach's H.	1140	B.	Guigou's Boarding House	1439
Pantherkill Mt.	3828	B.	Pine Hill Village	1512
Slide Mt.	4205	B.	Undercliff	2200
Helsinger Notch	2677	B.	Rose Notch	2743
Sprucetop	3567	B.	Birch Kill Notch	2334
Eagle Mt.	3560	B.	Monkey Hill (Mucky)	2489
		B.	Halcott Mt.	3504

vations above highwater of Rondout, by levels of the Ulster & Delaware Railroad; communicated by Geo. Coykendall, Supt.

ndout	2	Shandaken	1069
gston	155	Big Indian	1209
st Hurley	540	Summit	1886
re-Branch	511	Griffins' Corners	1516
oks Crossing	525	Dean's Corners	1344
dhead's Bridge	500	Halcottville	1399
kan	533	Strattons' Falls	1456
ceville	598	Roxbury	1497
unt Pleasant	690	Grand Gorge	1570
oenicia	790	Stamford	1767
Hollow	996		

RT. LVIII.—*Recent Explorations in the Wappinger Valley Limestone of Dutchess County, N. Y.*; by Professor W. B. DWIGHT, Vassar College, Poughkeepsie, N. Y. With plate XXI.

O. 3.—DESCRIPTION OF A NEW DISCINOID BRACHIOPOD FROM THE TRENTON AT NEWBURGH, N. Y.

IN a recent article on a locality of Trenton limestone at Newirgh, N. Y.,* the writer mentioned his discovery of a new Discina" at this spot, reserving its description till a more orough study could be made of it. I am happy to acknowlge my indebtedness in this examination to the cordial and ry valuable assistance of Mr. R. P. Whitfield, especially in solving the internal characteristics.

It has become evident that its features remove it from the nus Discina, to which I had at first referred it, the chief ints of distinction being the position of the peduncular oove in the more conical valve, while in Discina it occurs in

* This Journal, January, 1880.

the less conical one, and, more especially, the marked difference in the character of the muscular impressions.

It is quite possible that it represents a new genus, but I will refer it provisionally to that one of the Discinoid genera to which it seems the more closely related.

*Orbiculoidea** *conica*, sp. nov.—Shell black and flinty, sub-orbicular; longest diameter 12^{mm} or less; eminently lamellose in character. Ventral valve highly conical, varying from a quite regular cone with a slightly flaring margin, to a lower cone with widely flaring margin, and sometimes assuming sub-cylindrical and gibbous forms; apex pointed, sub-central, elevated in many specimens ⅓ a diameter or more above the marginal plane; peduncular groove ovate, extending from ⅓ to ½ the distance from the apex to the margin, foramen at the wider part, i. e. at the end most distant from the apex. Dorsal valve either nearly flat, slightly convex, or somewhat concave; apex from ¼th to ⅓d of a diameter distant from the nearest part of the margin; and very slightly elevated.

Both valves are marked exteriorly by fine regular concentric ridges, 100 to an inch near the margin, 150 to an inch on the general surface, but rapidly increasing in fineness around the apex to 250 to an inch, and there becoming very shallow or entirely disappearing as shown in plate XXI, figure 8.

These ridges are often sharp, giving a serrated outline to a cross section in much weathered individuals, but in such as are well-preserved, they are smoothly rounded, as are also the valleys between, but slightly steeper on the apical side.

In the best specimens of the internal markings of the flatter (dorsal) valve, there is a deep marginal pallial impression, and there are two large well-marked pyriform muscular impressions nearly central, diverging toward their broader portions posteriorly, leaving a V-shaped tract between, which is often marked by a central line or fissure. There are apparently faint traces of two additional and smaller muscular impressions between the above and the posterior margin and near to the latter; these are however very doubtful. The internal character of the conical ventral valve cannot be satisfactorily discovered from any of the specimens on hand.

This fossil is remarkable for the position of the foramen at the distal extremity of the peduncular groove—and still more for its marked crania-like arrangement of muscular impressions.

I have found it only in a small tract of rock mostly at one end of the exposure of Trenton, which I described in my last paper as exhibited 2¾ miles north of Newburgh, N. Y.; but hundreds of fragments of this fossil are lying in close contiguity within four or five hundred square feet of surface. The speci-

* D'Orbigny.

mens are so exceedingly brittle as to render them difficult of extraction without injury, and as to require great caution in the handling after they are secured. Of the ventral valve, I have found but four or five sufficiently perfect to show the peduncular groove; of the dorsal valve I have obtained twice as many which are fair specimens. The comparison of the many fragments, and of cross sections exhibited in broken rock, has served to confirm what is indicated in the more perfect individuals. In no instance have the two valves been found united, nor has it been possible to obtain an equally satisfactory exhibition of the general surface of both sides of the same individual valve; for the action of acid in separating the imbedded side from the rock is apt to flake it off injuriously. The margins of the specimens are almost invariably in a broken state.

The shell has been above described as lamellose. I have not been able to detect any punctate structure. In some cases, especially in weathered specimens, the external ridges assume a minutely tuberculous character, apparently due to delicate radiating lines of internal structure more than of external form, which may be detected in certain individuals crossing both the ridges and the inter spaces; these enable the points at which they cross the ridges to resist weathering more than the adjoining parts. In most cases, however, nothing but the simple concentric lines of the ridges are visible.

EXPLANATION OF PLATE.

Figures 1, 2 and 3.—Apical portions of the lower (ventral) valve of three different individuals, actual size, showing the peduncular groove. No. 3 shows a tendency toward a cylindrical form.

Figure 1 *a*.—A view of specimen figure 1, enlarged 2½ diameters, to show the shape of the groove, the position of the foramen (at *f*,) and the strongly marked concentric ridges.

Figure 4.—Another lower valve, actual size, exhibiting a broadly flattened margin, to the diminution of the height of the apex.

Figure 5.—The largest lower valve yet found; nearly a regular cone; the marginal edge wanting; (actual size.)

Figure 6.—A fragment of an upper (dorsal) valve, actual size, showing the apex and considerable concavity of the surface between the apex and anterior margin.

Figure 7.—A nearly perfect and very flat specimen of the upper valve showing the apex slightly elevated and about ⅓ diameter from the nearest margin.

Figure 7 *a*.—Same, magnified two diameters to show concentric ridges.

Figure 8.—A cross section through a portion of the upper valve, extending from the apex at *a*, a short distance toward the anterior margin, magnified nine times, showing the laminations of the shell and the character of the ridges.

Figure 9.—A cross section of upper valve, near posterior margin, parallel to the shorter diameter.

Figures 10 and 11.—Interiors of upper valves of two individuals, actual size, showing clearly the pallial impression and one pair of muscular impressions with some indications of a second pair near the posterior margin (lower part of the figure.)

Figure 11 *a*.—An enlargement, two diameters, of specimen figure 11.

Figure 12.—An ideal profile of the two valves united and in position.

ART. LIX.—*The Color Correction of certain Achromatic Object Glasses;* by Prof. C. A. YOUNG, Princeton, New Jersey.

THE recent discussions in this Journal upon the theory of achromatism will perhaps give interest to a brief statement of the results actually obtained in practice. I accordingly present the results of my measurements upon two excellent object-glasses which have come under my observation.

The first is that of the Dartmouth College Equatorial, made by the Clarks in 1871. It has an aperture of 9·36 inches and a focal length of 12 feet. It is considered by the makers a little under-corrected, but suits my own eye very well, in pleasant contrast to the violent over-correction of a 6-inch Munich glass which I had used for several years previous. The spherical aberration is very perfectly corrected. The curves are essentially those of Littrow (Mem. Roy. Astron. Soc., vol. iii), a nearly equiconvex lens of crown, and a nearly plano-concave flint.

The other lens is that of the Equatorial belonging to the observatory of the John C. Green School of Science at Princeton. It has an aperture of 9·5 inches and a focal length of 138. It is constructed substantially upon the curves proposed by Gauss (Gauss' Werke, vol. v, p. 507, Göttingen Ed.), the radii and constants of the objective being as follows, viz:

		Inches.
Crown lens, meniscus, convex side outward	Radius of convex surface,	16·572
	Radius of concave surface,	57·425
	Thickness at center,	0·620
	Interval between lenses,	0·312
Flint lens, concavo convex, convex side next crown,	Radius of convex surface,	20·684
	Radius of concave surface,	13·871
	Thickness at center,	0·305

The radii were determined by a delicate spherometer.

The telescope is remarkably excellent in every respect, especially in the darkness of the field and the power of exhibiting faint objects, like the satellites of Mars and Uranus.

The observations on the Dartmouth telescope were made by myself in 1872; those on the Princeton instrument in 1879, partly by myself and partly by my assistant, Mr. McNeill. The number of observations on the Princeton telescope was from ten to twenty for each line of the spectrum examined; the figures for the Dartmouth instrument depend upon only five measurements each, and are of course somewhat less reliable.

The method of observation was in all cases substantially the

same. The spectroscope, arranged as for observation of solar prominences, is attached to the telescope, which is first pointed at the center of the sun. The portion of the spectrum to be examined is then brought to the middle of the field of view, and one of the longitudinal dust-lines (caused by particles between the jaws of the slit, always far more abundant than one would like) is made perfectly distinct by the focussing screw of the spectroscope. If the parts of the spectroscope all happen to be in exact adjustment, the true dark lines of the spectrum and these dust-lines will of course both be perfectly sharp for the same focal adjustment; but this is seldom the case for a fastidious eye.

This adjustment of focus having been accurately made, the telescope is then so directed that the edge of the sun's image shall cross the slit perpendicularly, and by sliding the whole spectroscope along its supporting bar a position is sought where the edge of the solar spectrum shall be perfectly defined as seen in the eyepiece of the spectroscope. When this has been accomplished the slit will evidently be exactly in the focal plane of those rays of the spectrum which occupy the field of view.

Of course if the object-glass is poor, or the air unsteady, no point of absolute sharpness can be found, and we have to be content with finding a minimum of indistinctness. But with good seeing and an object-glass well corrected for spherical aberration, the observation admits a really surprising degree of accuracy, successive determinations of the same point seldom differing, under such circumstances, as much as half a millimeter.

In this way the differences of focal length for different parts of the spectrum may be obtained with satisfactory precision: I say *differences* because the absolute focal length is all the time changing with the temperature, and that by a considerable amount; so that it is necessary to recur to and redetermine the zero point continually. This zero in my observations was the focal plane of the D lines.

In the table the first column contains the designation of the spectrum-lines observed, either by letters, or by their position on Kirchoff's map; the second gives the wave length according to Ångström. The remaining columns explain themselves, except that dF denotes the difference, expressed in thousandths of an inch, between the minimum focal length, and that for the particular ray of the spectrum in question, while the columns headed $\frac{dF}{F}$ contain the same quantity expressed in hundred thousandths of the focal length. I have added, for comparison, in the sixth column, the results of Lorenzoni for a Fraunhofer

object-glass of 1m·750 focal length; published in the Astronomische Nachrichten, vol. lxxviii, p. 289 (1871). His numbers were obtained by calculation and not by direct measurement, the computation being based upon Fraunhofer's determination of the indices of refraction for specimens of glass like that used in the lens.

Ray of Spectrum.		Gauss.		Littrow.	Fraunhofer.
Designation.	λ.	dF	$\frac{dF}{F}$	$\frac{dF}{F}$	$\frac{dF}{F}$
A	7600	0·199 in.	·00145	·00172	--
B	6866	·097	69	97	·00064?
C	6561	·052	37	49	52
D	5890	·002	1	0	2
1235 K	5590	·000	0	--	--
1474 K	5316	·004	3	35	--
E	5269	---	--	--	15
b	5183	·011	8	--	25
c	4956	·035	25	--	--
F	4860	·059	42	129?	72
2500 K	4530	·197	143	--	--
f	4471	---	---	--	214
2796 K	4340	---	---	294	271
G	4307	·370	262	--	289
h	4101	·626	437	444?	452
H	3968	·810 in.	·00575	·00650?	·00582

A glance at the table shows that as to the extreme rays there is very little difference between the three objectives, but that for the middle rays the Gauss lens is decidedly the best, and the Littrow the worst. The same thing is still better shown by the diagram of the color curves. The ordinates of these curves are taken from the columns $\left(\frac{dF}{F}\right)$ of the table: for abscissas I have used the values of $\frac{1}{\lambda}$, i. e., the number of wave-lengths to a millimeter. If we take the wave lengths themselves as abscissas, the left-hand portion of the curve is so flattened and extended, and the right-hand portion becomes so steep as to make the figure very inconvenient.

A ? is appended in the table to a few of the numbers which do not seem to fall in well with the general course of the curve to which they ought to conform.

Princeton, N. J., April 14, 1880.

ART. LX.—*Note on the Companion of Sirius;* by ASAPH HALL.

IN 1844, Bessel showed by a careful discussion of the observations of Sirius, that the right ascensions of this star could not be represented within the limits of their probable errors by means of a uniform proper motion. The residuals were distributed in a periodical form; and Bessel, after a simple and ingenious transformation of the equations of motion, and the assumption of a value for the annual parallax of Sirius, was led to infer the existence of a dark body near this star that disturbed its proper motion. This, indeed, seemed to be the only reasonable hypothesis left. It is evident, if we imagine such a system, that while the center of gravity of the two bodies would move in a right line, or apparently on the arc of a great circle, the stars themselves would be subject to periodical variations in their motions. Bessel's conclusion was criticised by W. Struve, in his studies on stellar astronomy, page 53 of the notes, who decided that Bessel was mistaken; but Struve's criticism does not seem to be well founded, and in 1851, Dr. C. A. F. Peters showed, in a very complete investigation of this question, that the observations of right ascension fully confirm Bessel's opinion. Peters also computed an orbit of the disturbing body, and found the time of its revolution to be fifty years. In 1861, Professor T. H. Safford found that the observations of declination indicate a similar disturbing force. In January, 1862, Mr. Alvan G. Clark discovered a companion of Sirius very nearly in the position pointed out by theory, thus confirming in a remarkable manner Bessel's hypothesis.

A very complete discussion of the observations of Sirius, both in right ascension and declination, and also of the micrometrical measurements of the Clark companion during the first five years after its discovery, was published by Professor Auwers in 1868. The identity of this companion with Bessel's disturbing body, is, in the opinion of Auwers, put beyond doubt by his investigation. The elements of the disturbing body found by him are nearly the same as those found before by Peters, and the accuracy with which the observations are represented by the elements is so great that confidence in the identity of the two bodies is fully justified. The weight to which this result is entitled is very great, especially since the variable proper motion of Sirius has been investigated by four able astronomers. Yet there are some things which seem to me to throw a slight degree of doubt on the identity of the Clark companion with Bessel's disturbing body: First, the relatively great mass of the companion, which, according to

Auwers, is one-half the mass of Sirius, or if we assume Gyldén's parallax of Sirius, 0″·193, seven times the mass of our sun. Unless, therefore, we assume a special constitution for this companion, it ought to shine with the brilliancy of a star of the first magnitude, while in fact it is only of about the ninth magnitude. But the assumption of a peculiar constitution of the companion is purely arbitrary, and is not in itself plausible. Some observers, indeed, claim to have seen a disk to the Clark companion, but a real disk visible at the distance of Sirius would correspond to an enormous body, nearly filling the orbit of Venus; and, moreover, most observers have failed to see a disk.

Again, the micrometrical observations now extend over eighteen years, or more than one-third of the period of the disturbing body as determined by Peters and Auwers from the periodical variations in the right ascensions and declinations of Sirius, and these observations furnish some knowledge of the probable period of the Clark companion. The difference between the positions predicted by Auwers and the observed positions is not indeed very great, but the micrometrical observations indicate, I think, that the periodic time of the Clark companion will prove to be decidedly greater than what the disturbed motion of Sirius calls for. On this point we can not yet speak with confidence, but the doubt raised by the micrometrical measurements is sufficient, I think, to justify a suspension of judgment, and to incite astronomers to make careful observations of this interesting object. These measurements were begun in 1862 by Professor Geo. P. Bond, who found for that epoch

	p.	*s.*
1862.19	84°·61	10″·07

My own observations for the last seven years, together with the residual found by comparing with Auwers' predicted places, are given in the following table:

Date.	*p.*	*s.*	C — O.	
			Δ*p.*	Δ*s.*
1874.23	58°·05	11″·11	+7°·08	−0″·19
1875.28	56·38	11·08	+6·99	−0·34
1876.22	55·22	11·19	+6·47	−0·65
1877.26	53·38	10·95	+6·46	−0·68
1878.24	51·68	10·76	+6·24	−0·79
1879.20	50·13	10·57	+5·84	−0·91
1880.25	47·83	10·30	+5·81	−1·08

It is not worth while to speculate on these residuals, since we are now approaching a critical time, and a few more years of careful observation will go far towards deciding the question of identity.

April 9, 1880.

ART. LXI.—*Study of the Emmet County Meteorite, that fell near Estherville, Emmet County, Iowa, May* 10, 1879; by J. LAWRENCE SMITH, Louisville, Ky.

THE fall of this meteorite is in all its attendant circumstances one of the most remarkable on record. I therefore visited the region, on my return to America some months after its fall, and saw the two large masses which are the main representatives. Several short notices have already appeared on the subject; among them, one each, by Professor Shepard, Professor Peckham and Professor Hinrichs; and in describing the physical and chemical characteristics of the original masses, I shall be obliged to repeat some details that have been brought out.

Locality.—The place of fall is near Estherville, Emmet County, Iowa, just on the boundary of the State of Minnesota, lat. 43° 30′, lon. 94° 50′, within that region of the United States which has become remarkable for falls of meteorites, and of which I gave an outline map in my article on "the three meteorites that fell at Rochester in Indiana, Cynthiana in Kentucky, and Warrington in Missouri, within the space of one month."*

The State of Iowa has become particularly conspicuous in recent years as the landing place of these celestial messengers; and I now have under examination still another remarkable one with some peculiar physical characters, but about which I have not yet obtained the historic details.

The *phenomena accompanying the fall* were of the usual character, but on a grander scale. It occurred about five o'clock in the afternoon, under a clear sky, with the sun shining brightly. In some places the meteorite was plainly visible in its passage through the air, and looked like a ball of fire with a long train of vapor or cloud of fire behind it; and one observer saw it 100 miles from where it fell. Its course was from northwest to southeast. The sounds produced in its course are referred to as being "terrible" and "indescribable," as scaring cattle and terrifying the people over an area many miles in diameter. At first they were louder than that of the largest artillery; these were followed by a rumbling noise, as of a train of cars crossing a bridge. The concussion when it struck the ground was sensible to many persons, and it is reported that the soil was thrown into the air at the edge of a ravine where the largest of the masses was found. Two individuals were within two or three hundred yards of the spots where the two larger masses fell.

* This Journal, vol. xiv, 1877.

There were distinctly two explosions. The first took place at a considerable height in the atmosphere, and several large fragments were projected to different points over an area of four square miles, the largest mass going farthest to the east. Another explosion occurred just before reaching the ground, and this accounts for the small fragments found near the largest mass.

Impact with the earth.—A remarkable fact connected with the fall, besides that of the local disturbance of the earth alluded to, is the depth to which the mass penetrated. Had the fall taken place during the night, I doubt if the largest fragment would have been found. It struck within 200 feet of a dwelling house, at a spot where there was a hole (previously made) six feet deep and over twelve feet in diameter, filled with water, and having a bottom of stiff clay. This clay was excavated to a depth of eight feet before the meteorite was discovered, and two or three days elapsed before it was reached. Its total depth below the general surface of the ground was hence fourteen feet.

The second large mass was found embedded in blue clay about five feet below the surface, at a place two miles distant from the first. The third of the three largest masses was not discovered until the 23d of February, 1880, more than nine months after the fall, and its locality was four miles from the first. A trapper on the prairies, who had witnessed the original occurrence, observed a hole in a dried-up slough; on sounding it with his rat spear, he detected a hard body at the bottom, and on digging found the stone at a depth of five feet. Some small fragments were doubtless detached when the large mass approached the ground, as they were discovered near to it. The fragments thus far obtained weighed respectively, 437, 170, 92½, 28, 10½, 4 and 2 pounds.

Height and velocity.—A railroad engineer who observed it before the report, estimated its height to be forty miles, but at the time of the explosion much less; from an imperfect computation, he considered its velocity to be from two to four miles per second.

External characters. — The masses are rough and knotted like large mulberry calculi, with rounded protuberances projecting from the surface on every side; the black coating is not uniform, being most marked between the projections. These projections have sometimes a bright metallic surface, showing them to consist of nodules of iron; and they also contain large lumps of an olive-green mineral, having a distinct and easy cleavage, which is more distinct where the surface has been broken. The greater portion of the stony material is of a gray color, with this green mineral irregularly disseminated

through it. The two minerals are mixed under various forms; sometimes the green mineral is in small rounded particles intimately mingled with the gray, at other times it is in small cavities in minute crystalline fragments, without any distinct faces, and almost colorless. The masses are quite heavy and vary much in specific gravity in their different parts; but the average cannot be less than 4·5. When broken, one is immediately struck with the large *nodules* of metal among the gray and green stony substances, some of which will weigh 100 grams or more. In this respect this meteorite is unique, it differing entirely from the mixed meteorites of Pallas, Atacama, etc., or the known meteoric stones rich in iron; for in none of these has the iron this nodular character.

Another striking feature in the relation of the iron and stony matter is, that the larger nodules of iron appear to have shrunk away from the matrix; an elongated fissure of from one to three millimeters sometimes intervening, separating the matrix and nodules to the extent of one-half the circumference of the latter, and appearing as if the iron had contracted from the stony matrix during the process of cooling. There are numerous small cavities of various sizes, where there are not any iron nodules, and where the minerals appear more crystalline, indicating an irregular shrinkage during the consolidation.

The minerals.—At first sight I expected to find more than two earthy minerals. The microscope gave, as with most meteoric stones, unsatisfactory results. I therefore tried to separate the stony minerals mechanically; the only mineral that I was enabled to obtain pure in sufficient quantity, has an olive green color, and occurs in masses of from one-half to one inch in size, having an easy cleavage, especially in one direction; this is proved to be *olivine.* The same mineral occurs also in minute rounded concretions in other parts of the meteorite; and minute, almost colorless crystalline particles in the cavities I take to be olivine. *Nickeliferous* iron, as already stated, is very abundant. *Troilite* exists in small quantity. *Chromite* was also found.

That the stony part of this meteorite consists essentially of bronzite and olivine will be seen from the chemical investigation, which found only three essential constituents, viz: silica, ferrous oxides and magnesia. Another silicate will be referred to beyond, consisting of the same oxides, but in different proportions from either bronzite or olivine.

Chemical constitution.—The stony part, pulverized and freed as far as possible from metallic iron by the aid of the magnet, when treated with chlorhydric acid on a water bath for several hours, is resolved into soluble and insoluble parts, the propor-

tions varying very much with different fragments, and ranging from 16 to 60 per cent for the soluble part. This soluble part consists of silica, ferrous oxide and magnesia, and without a trace of lime, thus indicating the absence of anorthite.

(1) *Insoluble portion.*—The insoluble portion was carefully analyzed by fusion with carbonate of soda, and found to contain:

		Oxygen ratio.
Silica	54·12	29·12
Ferrous oxide	21·05	4·67
Chromic oxide	trace	
Magnesia	24·50	9·80
Soda with traces of potash and lithia	·09	·023
Alumina	·03	·013
	99·29	

The oxygen ratio clearly indicates the mineral to be $\dot{Si}\dot{R}$, being virtually $\dot{Si}(\dot{Mg}\dot{Fe})$, or the common form of *bronzite* contained in meteorites.

(2) *Soluble portion.*—On testing the green mineral already referred to I found that this was the soluble portion, and it was readily detected in a pure state from the stony part of the meteorite. Its cleavage in one direction is very perfect; its specific gravity 3·35; hardness almost 7; pulverized, it is readily and completely decomposed by hydrochloric acid. Two analyses were made, one by decomposing it directly with hydrochloric acid over a water bath, and the other by first fusing it with carbonate of soda—the two analyses agreeing perfectly.

		Oxygen ratio.
Silica	41·50	22·13
Ferrous oxide	14·21	3·12
Magnesia	44·64	17·86
	100·35	

The above analysis gives the formula $\dot{Si}\dot{R}_2$, or that of olivine.

(3) *Opalescent silicate.*—In some parts of this meteorite, a silicate occurs, that is opalescent, of a light greenish-yellow color, and cleaves readily. In one instance I observed it making a notable projection on the surface. Although I had a number of fragments of the meteorite for examination, amounting to ten or twelve pounds, I did not obtain enough of the mineral to establish positively its true character, but I hope to obtain more. An analysis was made with about 100 milligrams of the pure mineral with the following result:

		Oxygen ratio.
Silica	49·60	26·12
Ferrous oxide	15·78	3·50
Magnesia	33·01	13·21
	98·39	

Equivalent to $\ddot{S}i\dot{R}_3+\ddot{S}i_2\dot{R}$, one atom of bronzite plus one atom of olivine, a form of silicate that we might expect to find in meteorites.

(4) *The nickeliferous iron.*—As already stated this iron is abundant in the meteorite, and sometimes in large nodules of 50 to 100 grams; on a polished surface the Widmanstättian figures are beautifully developed by acid. On analysis it was found to contain:

Iron	92·001
Nickel	7·100
Cobalt	·690
Copper	minute quantity.
Phosphorus	·112
	99·903

(5) *Troilite.*—The proportion of troilite is not large, and it could be detached only in small fragments.

(6) *Chromite.*—When small pulverulent fragments of the meteorite are heated with hydrochloric acid for some time and the residual matter washed and dried, it is easy to find particles of the stony mineral more or less filled with minute black shining particles which are chromite.

The constitution of this meteorite, so far as I have been able to make it out, is therefore as follows:

Bronzite, abundant; *olivine*, abundant; *nickeliferous iron*, abundant; *troilite*, in moderate quantity; *chromite*, in minute quantity; *silicate*, not yet well determined.

It will be thus seen that in its composition the meteorite contains nothing that is peculiar. I should, however, give it a unique position among meteorites, on account of the phenomena accompanying its fall, especially the great depth to which it penetrated beneath the surface, and also because of its physical characters and the manner of association of its mineral constituents. I examined carefully for feldspar and schreibersite; but the absence of both lime and alumina (except as a trace) clearly proved the absence of anorthite; and the small particles of the mineral that might have been taken for schreibersite were found on examination in all instances to be troilite.

ART. LXII.—*The Oxidation of Hydrochloric Acid Solutions of Antimony in the Atmosphere;* by JOSIAH P. COOKE. (Contributions from the Chemical Laboratory of Harvard College.)

IN our original paper on the Atomic Weight of Antimony—Proceedings of the American Academy of Arts and Sciences, vol. xiii, page 21—we made the following incidental observation in explanation of certain precautions which we found to be necessary in order to secure the precipitation of pure antimonious sulphide:

"The precautions here described may seem unnecessary to those who are not familiar with the fact that a solution of antimony in hydrochloric acid oxidizes with very great rapidity in the air,—fully as rapidly as the solution of a ferrous salt. A solution reduced as we have described, which has at first no action on the iodized starch paste, will strike the blue color after it has been exposed to the air for only a few minutes. This property of an acid solution of antimonious chloride is mentioned by Dexter, in the paper already referred to, but we were wholly surprised by the energy of the action. By means of it, antimony can be dissolved in hydrochloric acid without the aid of nitric acid, or of any other oxidizing agent save the air, if only a certain amount of antimonious chloride has once been formed. When, after exposure to the air, the solution is boiled over pulverized antimony, the solution is reduced, and a further portion of the metal enters into solution. After a second exposure, the same process can be repeated, and so on indefinitely. The process is very slow and tedious, but, in one experiment, we succeeded in bringing into solution in this way several grams of antimony."

On the sole basis of this language we have been represented as asserting that such antimony solutions oxidize in the air as rapidly as a solution of *ferrous chloride*, and experiments on comparatively dilute solutions of antimonious oxide in hydrochloric acid have been adduced as proofs that our observation was incorrect.

As is evident from the context, the statement just quoted, although the result of a very extended experience, was not based on quantitative measurements. What we noticed was that the solutions *were very quickly acted on* by the oxygen of the atmosphere, and we freely admit that the expression here italicized is a more accurate description of our observation, than the words originally used as quoted above. But our meaning was not left in doubt, for we expressly say immediately after, that the process is very slow and tedious. In regard to the phenomenon in question, the effects are so obvi-

ous when once attention is called to them, that it is entirely unnecessary to confirm our previous observations except so far as to add the following quantitative determinations, which will serve to give an accurate idea of the extent of the action under the only conditions we have investigated, or in regard to which we have written.

In order to determine the amount of oxidation caused by the action of the atmosphere on a solution of antimony in hydrochloric acid, we reduced the oxidized solution by boiling the liquid over antimony bullets, and determined the loss in their weight. This method is fully described in our original paper, and is based not only on the reducing power of the metal, but also on the fact repeatedly observed, that after the reduction was complete, the smallest excess of the finely pulverized metal would not dissolve even after prolonged boiling, and in the presence of a large excess of acid, if only the solution was protected from oxidation.

We began our experiments by dissolving 1·0036 grams of pure antimony (a portion of the same used in our experiments on the synthesis of antimonious sulphide) in about 30 cubic centimeters of pure hydrochloric acid (sp. gr. = 1·175) adding 3 cubic centimeters of very dilute nitric acid (containing only about 5·4 per cent of HNO_3). After the solution was completed we added bullets made of pure antimony (the same that had been used in our previous experiments), and boiled the solution in an atmosphere of carbonic dioxide, using the same apparatus which we described in our previous paper (loc. cit.) After the reduction was ended, the solution was transferred to a flat-bottomed flask through a platinum tunnel, on which the bullets were retained, and after washing into the flask the last traces of the solution with as small an amount of hydrochloric acid as possible, the tunnel was removed, the bullets washed with water, and again weighed as at first on the platinum tunnel. In reducing the original solution 0·4100 of a gram of antimony were dissolved from the bullets. The solution now containing 1·4136 grams of antimony was next exposed to the air for different successive periods of time in a room having a varying temperature of from 15° to 30°, sometimes in the shade, and at other times on a window seat where the sun's direct rays fell on the flask during several hours of each clear day.

We give in the following table the weight of antimony dissolved from the bullets after each successive exposure to the air; the amounts in each case being determined with all the precautions described above and still more at length in our former paper:

Weight of Sb originally dissolved				1·4136	
1. Dissolved from balls after 3 days' exposure,				0·0150	
2. do. after 5 days'				0·0295	
3. do.	" 10	"	May 17 to May 27,	0·0600	
4. do.	" 23	"	May 27 to June 19,	0·1340	
5. do.	" 37	"	June 19 to July 26,	0·2960	
6. do.	" 120	"	July 26 to Dec. 24,	0·4481	0·9826

During these experiments the volume of the solution was gradually increased by the hydrochloric acid used in washing as above described, so that at last the volume amounted to 100 cubic centimeters.

It will be noticed that the amount of oxidation increased with the time of exposure, and that so long as the amount was small it was as nearly proportional to the time as could be expected under the varying conditions. The increased activity shown by determination No. 5 appeared to be due to the intensely warm weather and bright sunshine during the period, and the last determination would seem to indicate that after the oxidation reached a certain limit the process went on more slowly as we should naturally expect, but, with the greatly varying conditions during this long period, no certain conclusion can be drawn in regard to the effect of any single cause.

The action we are discussing is entirely in harmony with the chemical relations of antimony. The most striking characteristic of this elementary substance is its tendency to form compounds of the radical antimonyl. SbO. The oxichlorides, the oxibromides and the oxi-iodides whose relations we have discussed so fully in our previous papers, are examples in point, and we have been continually surprised by the appearance of such compounds in reactions in the most unexpected ways. In this respect antimony closely resembles vanadium, and with this element antimony is more closely allied than with its familiar associate, arsenic. What the precise reaction is in the present case, we are not prepared to state. That it is not the simple conversion of a terchloride into a pentachloride we are convinced, and investigations are in progress which we hope will further elucidate the subject.

In this connection we may appropriately add that while the above determinations were in progress we repeated the experiment described on page 19 of our previous paper (loc. cit.). We treated in an open flask 5 grams of finely-powdered pure metallic antimony with 50 cubic centimeters of strong and pure hydrochloric acid, to which we added only one cubic centimeter of the very dilute nitric acid (5·4 per cent) described above. The flask was placed in a warm protected place (30° C.) and shaken from time to time. Soon the acid became col-

ored reddish-yellow and the chemical action began. When it had apparently ceased, the contents of the flask were shaken together, and the solution became at once as colorless as water. But on standing in the air the color rapidly returned, spreading from the surface of the liquid downward. These phenomena were repeated again and again during four or five months, until the whole of the metal dissolved. According to the reaction usually assumed to take place under these circumstances, 5 grams of metal would have required 50 cubic centimeters of acid, so that the effect was obtained with only one-fiftieth of the amount required by this theory.

ART. LXIII.—*Note on a Relation between the Colors and Magnitudes of the Components of Binary Stars;* by EDWARD S. HOLDEN.

MUCH has been written on the colors of stars, but I do not know that a relation has been found between the magnitudes and the colors of binary stars such as is shown by the following tables.

In 1877 I noticed that, in a general way, the difference of the magnitudes of the two components A and B of a double star was less, the nearer A and B were of the same color to the eye. If this was not the result of chance but the consequence of some physical law, the relation should come out with greater distinctness when the stars chosen were certainly binary and not merely double. In this way, what would be lost by the exclusion of many pairs *probably* associated physically, would be more than compensated by the exclusion of all cases of mere accidental association—optically double stars. I therefore requested my friend, Mr. S. W. Burnham, to give me a list of all the stars which were certainly binary, which he has kindly drawn up. See Tables I and II.

Table I contains 122 stars certainly binary and with component stars of like color. The magnitudes and colors are from the best authorities. The mean difference of magnitudes (B–A) is $0^{m}{\cdot}53$.

Table II contains forty stars certainly binary, the components being of different colors; the mean difference of magnitudes (B–A) is $2^{m}{\cdot}44$.

These tables show then that *considering every known case of binary stars of known color:* I. *The components of the* 122 *binary stars of the same color differ in magnitude on the average only* $0^{m}{\cdot}5$.

II. *The components of the* 40 *binary stars of different colors differ in magnitude on the average* $2^{m}{\cdot}4$. What the physical explanation of this curious relation may be, we have not now

enough knowledge to say. The following extracts seem, however, to be worth recording in this connection:

"Since spectrum-analysis shows that certain of the laws of terrestrial physics prevail in the sun and stars, there can be little doubt that the immediate source of solar and stellar light must be solid or liquid matter maintained in an intensely incandescent state, the result of an exceedingly high temperature. . . . . The light from incandescent solid or liquid bodies affords an unbroken spectrum containing rays of light of every degree of refrangibility within the portion of the spectrum which is visible. As this condition of the light is connected with the state of solidity or liquidity and not with the *chemical* nature of the body, it is highly probable that the light when first emitted from the photosphere . . . . would be in all cases identical. The source of the differences of color, therefore, is to be sought in the difference of the constituents of the investing atmospheres."*

This conclusion, that the characteristic colors of stars are always due to the absorptive action of their atmospheres, is to be compared with the two following facts. First, the color of a solid body cooling and not surrounded with an absorptive atmosphere, would, as it cooled, pass through the shades *white, yellow, orange, red,* but not through *green, blue,* or *purple.* Second, we do not find *isolated* stars of decided green, blue or purple colors. A few such have been recorded, but in most cases erroneously.† In general such stars are small, and as far as I know invariably associated with larger stars. That is, the isolated stars appear always of the colors which would arise in the cooling of solid or liquid masses and never as if necessarily surrounded with absorptive atmospheres—*i. e.* never decided violet or purple.

In a binary star where A is brighter than B, Table II shows that the colors are usually different, and Struve has pointed out that in the vast majority of such cases the component B is blue or purple. Arago has suggested that the condition of the small star is an index of what the larger star will in process of time become, in the order of evolution. But any progress of evolution which obtains in binary stars, should, one would think, obtain also in isolated stars. We have just seen that there are no isolated purple stars. Whence it would appear that the conditions are strangely different in the two cases. The foregoing simply shows the incomplete nature of the data in the case before us. The statements in italics seem to me of interest and importance, and they are borne out by the following tables.

* Huggins and Miller, on the Spectra of some of the fixed stars: Phil. Trans. 1864, p. 429.

† For example, Admiral Smyth calls α Lyræ a "green" star.

TABLE I (by S. W. BURNHAM).

Binary Stars (with components of same color).

	Double Star.	Name.	A. mag.	B. mag.	B-A. mag.	Color.	Authority.	Remarks.
1	OΣ187		7·3	7·3	0·0	Blanches	De	
2	Σ1187		7·1	8·0	0·9	Albæ	Σ	
3	Σ1196	ζ Cancri	5·0	5·7	0·7	Flavæ	Σ	
4	Σ1216		7·5	8·2	0·7	Albæ	Σ	
5	Σ3121		7·5	7·8	0·3	Albasubflavæ	Σ	
6	Σ1338		7·0	7·2	0·2	Albæ	Σ	
7	Σ1348	Lyncis 157	7·5	7·6	0·1	Albæ	Σ	
8	Σ1356	Hydræ 116	6·2	7·0	0·8	Flavæ	Σ	
9	OΣ208	ω Leonis	5·0	5·5	0·5	[No colors in OΣ.]		
10	A. Clark	φ Ursæ Maj.	5·5	5·7	0·2	[No colors.]		
11	Σ1423	8 Sextantis	8·6	9·3	0·7	Subflavæ	Σ	
12	Σ1457		7·4	8·4	1·0	Albsfl	Σ	
13	OΣ224		7·3	8·0	0·7	[No colors noted.]		
14	Σ1476		7·2	8·0	0·8	Albæ	Σ	
15	Σ1500		7·6	8·2	0·6	Subflavæ	Σ	
16	Σ1517		7·3	7·3	0·0	Subflavæ	Σ	
17	OΣ234		7·0	7·4	0·4	[No colors in OΣ.]		
18	Σ1643		8·4	8·7	0·3	Albæ	Σ	
19	Σ1647	Virginis191	7·5	7·8	0·3	Albæ	Σ	
20	Σ1670	γ Virginis	3·0	3·0	0·0	Subflavæ	Σ	
21	Σ1728	42 Comæ	6·0	6·0	0·0	Flavæ	Σ	
22	OΣ261		6·3	6·7	0·4	Blanches	De	
23	Σ1734		7·2	7·9	0·7	Albæ	Σ	B called blue by Secchi.
24	Σ 266		7·5	8·0	0 5	Blanches	De	
25	Σ1757		7·8	8·9	1·1	Albæ	Σ	
26	Σ1781		7·8	8·2	0·4	Albasubflavæ	Σ	
27	Σ1785		7·2	7·5	0·3	Albæ	Σ	
28	Σ1788		6·7	7·9	1·2	Albæ	Σ	
29	Σ1808		8·0	9·0	1·0	Albæ	Σ	
30	OΣ298		7·5	7·5	0·0	Blanches	De	
31	Σ1820		8·2	8·5	0·3	Subflavæ	Σ	
32	Σ1863		7·1	7·4	0·3	Albasubflavæ	Σ	
33	Σ1865	ζ Bootis	3·5	3·9	0·4	Albæ	Σ	
34	Σ1876		8·1	8·6	0·5	Subflavæ	Σ	
35	Σ1883		7·0	7·0	0·0	Subflavæ	Σ	
36	OΣ288		6·3	7·2	0·9	Blanches	De	
37	Σ3091		7·7	7·7	0·0	Flavæ	Σ	
38	Σ1934		8·5	8·5	0·0	Albæ	Σ	
39	Σ1932	Coronæ 1	5·6	6·1	0·5	Eg. albæ	Σ	
40	Σ1937		5·2	5·7	0·5	Flavæ	Σ	
41	Σ1938	μ^2 Bootis	6·7	7·3	0·6	Albasubvir.	Σ	
42	Σ 2.	Cephei 316	6·3	6·6	0·3	Flavæ	Σ	
43	Σ 13	Cephei 318	6·6	7·1	0·5	Subflavæ	Σ	
44	OΣ 12	λ Cassiopae	6·0	6·1	0·1	Blanches	De	
45	OΣ 20	66 Piscium	6·2	7·2	1·0	Blanches	De	Albasubfl.; albasubcaer, OΣ.
46	Σ 73	36Androm.	9·2	6·8	0·6	Aur.	Σ	
47	Σ 113	42 Ceti	6·2	7·2	1·0	Albæ	Σ	
48	H2036	Ceti 187	7·0	7·2	0·2	Blanches	De	
49	Σ 186		7·2	7·2	0·0	Albæ	Σ	
50	OΣ 38	γ Androm.	5.0	6·2	[1·2]	Caer.	Σ	See note * below.

* Color of Σ given of BC as a single star. OΣ noted no difference in components. Some observers have called them yellow: blue.

TABLE I.—Continued.

	Double Star.	Name.	A. mag.	B. mag.	B-A. mag.	Color.	Authority.	Remarks.
51	Σ 228	Andro. 259	6·7	7·6	0·9	Albæ	Σ	
52	Σ 234		7·8	8·7	0·9	Albæ	Σ	
53	Σ 257		7·2	7·7	0·5	Albsubflavæ	Σ	
54	Σ 305		7·3	8·2	0·9	Flavæ	Σ	
55	Σ 333	ε Arietis	5·7	6·0	0·3	Albæ	Σ	
56	Σ 367		8·0	8·0	0·0	Albsubflavæ	Σ	
57	OΣ 52	P III. 1	6·2	6·7	0·5	Blanches	De	OΣ, Albæ.
58	Σ 412	7 Tauri	6·6	6·7	0·1	Subflavæ	Σ	
59	Σ 511		7·5	8·0	0·5	Albæ	Σ	
60	Σ 572	Aurigæ 4	6·5	6·5	0·0	Subflavæ	Σ	
61	Σ 577		7·7	7·7	0·0	Albæ	Σ	
62	Σ 589		8·0	8·0	0·0	Albsubflavæ	Σ	
63	Σ 619		8·7	8·7	0·0	Albæ	Σ	
64	OΣ 98	14 Orionis	5·3	6·8	1·5	Blanches	De	
65	Σ 676		7·5	8·5	1·0	Albæ	Σ	
66	Σ 677		7·7	8·0	0·3	Eg. albæ	Σ	
67	Σ 728	32 Orionis	5·2	6·7	1·5	Subflavæ	Σ	
68	Σ 749		7·1	7·2	0·1	Eg. albæ	Σ	
69	Σ 910	P VI. 105	8·3	9·0	0·7	Subflavæ	Σ	
70	Σ 932		8·2	8·3	0·1	Albæ	Σ	
71	Σ 948	15 Lyncis	5·2	6·1	0·9	Albvir	Σ	
72	OΣ156		6·5	6·6	0·1	Blanches	De	
73	Σ1037		7·1	7·1	0·0	Subflavæ	Σ	
74	OΣ170		7·1	7·3	0·2	Blanches?	De	Flavæ, OΣ.
75	Σ1074		7·8	8·2	0·4	White	Σ	
76	Σ1081		7·8	8·5	0·7	Eg. albæ	Σ	
77	Σ1093		8·2	8·2	0·0	Albæ	Σ	
78	Σ1104		6·7	8·3	1·6	Albæ	Σ	
79	Σ1110	Castor	2·7	3·7	1·0	Subvir	Σ	
80	Σ1126		7·2	7·5	0·3	Subflavæ	Σ	
81	Σ1944		7·5	8·1	0·6	Albæ	Σ	
82	OΣ296		7·0	8·6	1·6	[No colors in De.]	δOΣ	
83	OΣ298		7·0	7·4	0·4	Blanches	De	
84	Σ1989	π^2 Urs. Min.	7·1	8·1	1·0	Eg. albæ	Σ	
85	Σ1998	ξ Scorpii	4·9	5·2	0·3	Albsubflavæ	Σ	
86	Σ2021	49 Serpen.	6·7	6·9	0·2	Albæ	Σ	
87	Σ2026		8·6	9·1	0·5	Flavæ	Σ	
88	Σ2106		6·7	8·4	1·7	Albæ	Σ	
89	Σ2118	20 Draconis	6·4	6·9	0·5	Albæ	Σ	
90	Σ2114		6·2	7·4	1·2	Albæ	Σ	
91	Σ2130	μ Draconis	5·0	5·1	0·1	Albæ	Σ	
92	Σ2173	Ophiu. 221	5·8	6·1	0·3	Eg. flav. seu Aurea	Σ	
93	Σ2199		7·2	7·8	0·6	Subflavæ	Σ	
94	OΣ338		6·5	7·7	1·3	Jaunes	De	
95	Σ2262	τ Ophiuchi	5·0	5·7	0·7	Subflavæ	Σ	
96	Σ2267		8·0	8·0	0·0	Albæ	Σ	
97	Σ2281	73 Ophiuchi	5·7	7·2	1·5	Albæ	Σ	
98	Σ2315	Hercul. 452	7·0	8·0	1·0	Albæ	Σ	
99	Σ2384		8·0	8·5	0·5	Flavæ	Σ	
100	Σ2383	ε^2 Lyræ	4·9	5·2	0·3	Eg. albæ	Σ	
101	Σ2422		7·6	7·7	0·1	Albæ	Σ	
102	Σ2438		7·0	7·6	0·6	Albæ	Σ	
103	Σ2509		7·0	8·1	1·1	Subflavæ	Σ	
104	Σ2525	Cygni 22	7·4	7·6	0·2	Subflavæ	Σ	
105	Σ2556		7·3	7·8	0·5	Albæ	Σ	

TABLE I.—Concluded.

	Double Star.	Name.	A. mag.	B. mag.	B-A. mag.	Color.	Au-thor-ity.	Remarks.
106	β 151	β Delphini	4·2	6·0	1·8	———		*
107	Σ2729	4 Aquarii	5·9	7·2	1·3	Flavæ	Σ	
108	Σ2737	ε Equulei	5·7	6·2	0·5	Subflavæ	Σ	
109	Σ2744		6·3	7·0	0·7	Albæ	Σ	
110	Σ2758	61 Cygni	5·3	5·9	0·6	Flav. seu Aurea	Σ	
111	OΣ535	δ Equulei	4·5	5·0	0·5	Eq. flavæ	Σ	
112	Σ2799	Pegasi 20	6·6	6·6	0·0	Subflavæ	Σ	
113	Σ2804	Pegasi 29	7·3	8·0	0·7	Albæ	Σ	
114	Σ2847		7·6	8·0	0·4	Subflavæ	Σ	
115	Σ2909	ζ Aquarii	4·0	4·1	0·1	Albasubvir	Σ	
116	Σ2912	37 Pegasi	5·8	7·2	1·4	Albæ	Σ	
117	Σ2928		8·0	8·0	0·0	Albæ	Σ	
118	Σ3006		8·5	9·0	0·5	Albæ	Σ	
119	OΣ495		7·4	7·4	0·0	Blanches	De	
120	Σ3046		8·0	8·5	0·5	Albasubflavæ	Σ	
121	Σ3050	Androm. 37	6·0	6·0	0·0	Subflavæ	Σ	
122	Σ3056		7·4	7·4	0·0	Subflavæ	Σ	†
123	Σ3062		6·9	8·0	1·1	Flava	Σ	No. 50 omitted.

* Σ called the large star, single to him, green. Certainly binary. None of the observers note any difference in color.

† Binaries, same color: Σ (B–A) = $64^{m}·2$; mean (B–A) = $0^{m}·53$.

TABLE II (by S. W. Burnham).

Binary Stars (with components of different color).

	Double Star.	Name.	A. mag.	B. mag.	B-A. mag.	Color A.	Color B.	Au-thor-ity.
1	Σ 60	η Cassiop.	2·0	7·6	5·6	Flava	Purpurea	Σ
2	Σ 208	10 Arietis	6·2	8·4	2·2	Flava	Cinerea	Σ
3	Σ 262	ι Cassiop.	4·2	7·1	2·9	Flava	Cærulea	Σ
4	Σ 295	84 Ceti	6·0	9·2	3·2	Flava	Cinerea	Σ
5	Σ 422	P III. 98	6·0	8·2	2·2	Aurea	Cærulea	Σ
6	Σ 460	Cephei 49	5·2	6·1	0·9	Flava	Subcærulea	Σ
7	Σ 535	Tauri 230	6·7	8·2	1·5	Subflava	Subcærulea	Σ
8	Σ 566	2 Camelop.	5·1	7·4	2·3	Flava	Subcærulea	Σ
9	β 86	β Leporis	3·5	10·0	6·5	Light gold	Light blue	De
10	Σ 742	Tauri 380	7·2	7·8	0·6	Subflava	Alba	Σ
11	Σ 963	14 Lyncis	5·9	7·1	1·2	Aurea	Purpurea	Σ
12	OΣ159	15 Lyncis	4·7	7·2	2·5	Jaune Clair	Azur Cendri	De
13	Σ 982	38 Gemino	5·4	7·7	2·3	Subflava	Subcærulea	Σ
14	Σ1066	δ Gemino	3·2	8·2	5·0	Subflava	Subpurpurea	Σ
15	Σ1273	ε Hydræ	3·8	7·8	4·0	Flava	Cærulea	Σ
16	Σ1356	ω Leonis	6·2	7·0	[0·8]	Flava	Cert. flava	Σ
17	Σ1374	Leo. Min. 30	7·0	8·3	1·3	Subflava	Eq. cærulea	Σ
18	OΣ215	P X. 23	6·5	7·3	[0·8]	Blanche	Blanc cendri	De
19	Σ1424	γ Leonis	2·0	3·5	1·5	Aurea	Rubrovir.	Σ
20	Σ1536	ι Leonis	3·9	7·1	3·2	Subflava	Cærulea	Σ
21	Σ1639	Comæ 68	6·7	7·9	1·2	Alba	Albasubcin.	Σ
22	Σ1768	25 Can. Ven.	5·7	7·6	1·9	Alba	Cærulea	Σ
23	Σ1877	ε Bootis	3·0	6·3	3·3	Eq. cærulea	Eq. cærulea	Σ
24	Σ1888	ξ Bootis	4·7	6·6	1·9	Flava	Rubropurpurea	Σ

TABLE II.—Concluded.

	Double Star.	Name.	A. mag.	B. mag.	B-A. mag.	Color A.	Color B.	Authority.
25	Σ1967	γ Coronæ	4·0	7·0	3·0	Albasubvir.	Purpurea	Σ
26	Σ2032	σ Coronæ	5·0	6·1	1·1	Subflava	Subcærulea	Σ
27	Σ2055	λ Ophiuchi	4·0	6·1	2·1	Flava	Subcærulea	Σ
28	Σ2084	ζ Herculis	3·0	6·5	3·5	Subflava	Subrubra	Σ
29	Σ2107	Hercul. 167	6·5	8·0	1·5	Subflava	Subcærulea	Σ
30	Σ2272	70 Ophiuchi	4·1	6·1	2·0	Flava	Purpurea	Σ
31	Σ2289	Hercul. 417	6·0	7·1	1·1	Flava	Subcærulea	Σ
32	Σ2382	ε' Lyræ	4·6	6·3	1·7	Albasubvir.	Albasabcærulea	Σ
33	Σ2579	δ Cygni	3·0	7·9	4·9	Subviridis	Cinerea	Σ
34	Σ2603	ε Draconis	4·0	7·6	3·6	Flava	Cærulea	Σ
35	OΣ413	λ Cygni	5·5	7·6	2·1	Blanche	Cendri Clair	De
36	A. G. Clark.	τ Cygni	4·9	7·4	2·5	Light yellow	Light blue	De
37	Σ2822	μ Cygni	4·0	5·0	1·0	Alba	Albasubcærulea	Σ
38	Σ2934		8·2	9·2	1·0	Albasubflava	Alba	Σ
39	OΣ483	52 Pegasi	6·0	8·0	2·0	Blanche	Cendri	De
40	OΣ489	π Cephei	4·4	7·5	3·1	Jaune Clair	Olivatre	De
41	Σ3001	o Cephei	5·2	7·8	2·6	Eq. flava	Eq. cærulea	Σ
42	OΣ507	B.A.C. 8277	6·3	7·7	1·4	Blanche	Cendri Olivatre	De

Binaries different colors: Σ (B–A) = 97^{m}·4; mean (B–A) = 2^{m}·44. (Nos. 16 and 18 omitted).

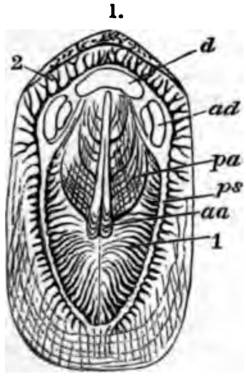
ART. LXIV.—*On the occurrence of true Lingula in the Trenton Limestones*; by R. P. WHITFIELD.

IT has been supposed by many that the Brachiopodous genus, *Lingula*, as represented by *Lingula anatina* Lamarck, a living species, was not represented among the fossil Lingulidæ of the older Paleozoic rock formations, if anywhere in rocks of Paleozoic age; and there has been a growing tendency to class all the Linguloid shells of these formations under other generic names. There is no question but that many of the forms represented in the Paleozoic rocks are really generically distinct from the living types; but I think we have proof in a species from the Trenton limestones of Wisconsin and Minnesota, that the true Lingulæ were represented by at least one species at that period. Several years ago I received from Dr. Aaron Elder, formerly of New York city, who had been spending a summer near Rochester, Minn., some internal casts of an undescribed Lingula. On examining them and finding the markings of the muscular scars and vascular lines very strong, I urged Dr. Elder to obtain more of the casts, at his next visit to that place, calling his attention particularly to these markings. During the following autumn I received other specimens, from some of which the accompanying figures and description of parts are taken. The species I propose to name *Lingula*

Elderi, after the discoverer, and a full description will be given, with figures, in the forthcoming Paleontological Report of the Geological Survey of Wisconsin.

The casts represent a species of moderate size, the average being about seven-eighths of an inch in length; the general outline is somewhat quadrate, the lateral margins being subparallel and a little convex, the upper end very obtusely angular or pointed, and the base rounded; the valves are convex, but the dorsal the most strongly so. The shell, when preserved, is smooth with very fine concentric lines, but presenting a polished appearance. The peculiar features are found in the preservation of the imprints left by the muscular and vascular scars on the shell, as copied on these internal casts, thus affording means of comparison with the corresponding organs of the living forms of the genus. These markings correspond more nearly to those of *L. anatina* Lam. than do those of any other

1.



2.

Silurian or Devonian species which I have ever examined, and although they do not exactly correspond still are as similar as one could expect in widely separated species. The variations consist in the position of the various muscular scars, and also somewhat in the lines of the pallial sinuses and in the ramifications of their branches. Nearly all the muscular areas have been identified on several individuals, and the anterior portion of the pallial sinuses with their interior ramifications, and the outer ones to a slight distance from the main trunks on most of them; while the ramifications of the posterior prolongations have been detected on two of the dorsal valves. I have not been able to trace all the elements of the muscular system, nor to detect the divisions between those forming the larger scars; some of which, in the recent forms, are seen to be composed of three or four elements; but where they are impressed so lightly on the shell and yet leave the trace of their advance over its

surface by the growth of the animal to interfere with their distinctness, this would scarcely be looked for in a fossil species.

On the cast of the dorsal valve (fig. 1) the impressions of the pallial sinuses (*p s*) are deeply marked and are widely separated, leaving the area within them very considerable; the central or inner ramifications (1) are very distinct, and the outer ones also for a short distance from the main branches; while the posterior branches (2) show the lateral ramifications only on the outer side. The divaricator muscular scar of the dorsal valve (*d*) is very large and curved forward at the sides, being situated well back near the apex of the valve. It has not been satisfactorily observed on the ventral side, as every specimen yet obtained has been more or less imperfect at this point, but it should be situated directly opposite that of the dorsal. The anterior adductor scars (*a a*) are small and situated near the center of the valve, while the posterior adductors (*p a*) are large and situated outside of, and posterior to them; so as to inclose their posterior ends. The scars of the adjustor muscles are distant from each other, and placed just within the posterior third of the length of the shell. Two elements can be detected in each scar on some individuals, but they are usually obscure.

In the ventral valve (fig. 2) the lines of the pallial sinuses are nearer together on the anterior half of the cast than on the other valve, which feature is remarkably similar to these lines as shown in *L. anatina*, but spread out rapidly toward the middle and on the posterior half occupy nearly the same relative position as on the dorsal side. Near the center of the valve are seen a pair of large scars which have progressed from behind, their track forming a strong feature on the cast, as it originates just in front of the divaricator muscle scar (*d*) and gradually widens as it advances until it occupies fully one-half the width of the cast near the middle of its length. In the central line of this track there is an elevated ridge which terminates in a slightly prolonged tongue and seems to represent the central adjustors (*c a*) and their track of advance. The large scars outside of these are probably the posterior adductors and external adjustors combined (*p a*), each scar being formed of two elements. Posterior to these and distant from the median line are other scars which are long and narrow, their length being parallel to the margin of the valve. These also have left their track of advance, having started from a point just in advance of the anterior margin of the divaricator muscle. Two elements are recognized on each side and represent the posterior adjustors and probably the anterior adductors combined (*p a* and *a a*.) Between the lines formed by the advance of the adjustor muscles and those occupying the central area, on each

valve are narrow, smooth, impressed spaces which unite with the lines of the pallial sinuses at the junction of the anterior and posterior branches, and extend to the position of the divaricator muscle scar. They are seen on all the specimens but I have not been able to identify them with any organs, and it is probable they are only the spaces of unoccupied shell between the scars of the adjacent muscles and their tracks of advance, as they are within the area of the muscles and consequently within the perivisceral chamber. The area of attachment of the posterior muscular walls of the perivisceral chamber have not been detected, unless they have occupied a portion of the area assigned to the posterior branches of the pallial sinuses as seen on the dorsal valve. In which case there could have been only external ramifications from this portion of those organs, instead of both external and internal, as in *L. anatina.*

In making these comparisons and in identifying the several muscles and other organs as represented on the casts, I have made use of the very excellent memoir "On the organization of the Brachiopoda," by Albany Hancock, Esq., published in the Trans. Phil. Soc. of England in 1858, a comparison with which cannot fail to convince any one of their intimate generic relations with *L. anatina.*

ART. LXV. — *Notes of Experiments upon Mr. Edison's Dynamometer, Dynamo-machine and Lamp;* by Professors C. F. BRACKETT and C. A. YOUNG, of Princeton, N. J.

DURING the experiments of Professors Rowland and Barker, the results of which appeared in the April number of this Journal, one of us (Professor Brackett) happened to be present; and he was requested by Mr. Edison to make an independent study of the subject under investigation.

Accordingly, we visited Menlo Park on March 19th and again on April 3d. On our first visit, we confined ourselves mainly to a study of the resistance, luminosity and efficiency of the lamp, making only a single test of the efficiency of the machine. On the second visit, we gave our attention to the dynamometer and the machine.

It is obvious that the work attempted in the time at our disposal was considerable; and, in consequence, no extreme accuracy is claimed for our results—though we believe them to be substantially correct—that is to say, within one or two per cent.

We first made a comparison of Mr. Edison's dynamometer with the well known Prony, the latter being driven through the former precisely as the dynamo-machine was, during the

trials made to determine its efficiency. We found that the Prony registered 93·2 per cent of the power transmitted by the Edison. This result we consider quite reliable, the 6·8 loss being reasonably accounted for by friction of counter-shaft journals and the slip of the belt intervening between the instruments.

To determine the efficiency of the dynamo-machine, we made three different tests. In all of them the power expended in driving the revolving armature was measured directly by the Edison dynamometer. The small additional amount spent in maintaining the field of force was calculated from the measured resistance of the magnet coils (1·47 ohms) and the difference of electric potential between the terminals of the coils, measured by a high resistance galvanometer (Thomson). It was assumed in this calculation that the machine which furnishes this current was of about the same efficiency as the one experimented on, it being of similar construction. The formula is

$$1{\cdot}25 \times 44{\cdot}25 \text{ ft. lbs.} \times \frac{V^2}{r} \times t,$$

where t is the duration of the experiment in minutes. V is the difference of potential in volts; r is the resistance or the coil 1·47 ohms. 44·25 is the number of foot lbs. of work done in one minute by an electromotive force of one volt driving a current through one ohm; and finally 1·25 is a factor embodying the assumption that the efficiency of the machine, producing the magnetizing current, is 80 per cent. The amount of this expenditure is trifling, not exceeding three per cent of the work used in driving the armature but its neglect might lead to misapprehension.

On March 19th the current produced was measured by the electrolytic method. We employed copper electrodes presenting opposed surfaces of about one square foot each, and placed about one inch apart in a solution of cupric sulphate. We also measured the resistance of the circuit by the bridge method both at the beginning and end of the experiment so as to take account of heating. For a check, we also measured the difference of potential between the terminals of the machine.

On April 3d we had recourse to the calorimeter, employing a resistance coil immersed in about 175 lbs. of water, the resistance of the coil being such that the work done elsewhere in the circuit could be calculated and allowed for as a small fraction of that directly measured. The difference of potential between the terminals was also measured for a check, as on March 19th. The resistance of the armature was 0·14 of an ohm; that of the rest of the circuit was made to vary in the different experiments, from 1·9 to 3·2 ohms.

We shall use the expression *available energy* to denote the energy developed in that part of the circuit which is outside of

the machine. The total energy of course includes that which is uselessly spent in heating the coils of the armature itself, a very small portion in this form of machine. Our results are as follows.

On March 19th the experiment lasted five minutes. We found:

Energy expended in driving armature ...	971,500	ft. lbs.
Energy expended on field of force	16,400	"
Total	987,900	"

The current calculated from the amount of copper deposited was 34·335 webers: the mean resistance of the circuit was 3·12 ohms, or, excluding the armature, 2·98 ohms. The electromotive force, indicated by the galvanometer, was 102·36 volts.

From these data we calculate:

Total energy realized in the current	814,400	ft. lbs.
Available energy (excluding armature) ..	777,200	"

Hence the total efficiency is 82·3 per cent, and the available efficiency 78·7 per cent.

On April 3rd the first test lasted $13^m\ 50^s$, and we found—

Energy expended in driving armature ..	2,844,600	ft. lbs.
Energy expended on field	19,634	"
Total...............	2,864,234	"

The total weight of calorimeter and its contents was 197·5 lbs. Making the proper reduction for weight, metals, thermometer, etc., we find the heat capacity of the whole to be 172·77 water lbs.

The rise in temperature, measured by a thermometer, easily read to $\frac{1}{50}$ of a degree, was 16·7° F.; and the precaution was taken to terminate the experiment when the temperature had risen as much above that of the air (71·2°) as it was below at the beginning, thus obviating the necessity of a radiation correction.

The resistance of the coil in the calorimeter was 1·72 ohms; that of the leading wires was only about 0·006, or $\frac{1}{300}$ of the preceding. Hence assuming 772 ft. lbs. as the mechanical equivalent of heat we have—

Energy developed in calorimeter.........	2,227,500	ft. lbs.
Energy developed in leading wires	7,425	"
Energy developed in armature...........	183,670	"

That is to say:

Total energy realized....................	2,418,600	"
Available energy realized	2,234,925	"

which makes the total efficiency 84·6 per cent and the available efficiency 78·2 per cent.

During the experiment the electromotive force of the current by which the field magnets were maintained was only 6·25 volts, consequently the machine was not giving nearly its maximum current—the energy expended being about 6·25 horse-power and the current about 46 webers.

During the next test, which continued nine minutes, the electromotive force of the field coils was maintained at 14·9 volts, and the current produced was 57·5 webers—consuming 9·5 horse power.

The calorimeter was refilled with fresh water; and proceeding as before we found—

Energy measured by dynamometer	2,827,550	ft. lbs.
Energy expended on field	72,180	"
Total	2,899,730	"
Energy realized in calorimeter	2,259,700	ft. lbs.
Energy realized in leading wires	7,532	"
Energy realized in armature	183,930	"
Total	2,451,162	"
Available	2,267,238	"
Total efficiency	84·5	per cent.
Available efficiency	78·2	"

These results were confirmed by the reading of the high resistance galvanometer.

Tabulating our results they stand thus:

	Total efficiency.	Available efficiency.
1st	82·3 per ct.	78·7 per ct.
2d	84·6 "	78·2 "
3d	84·6 "	78·2 "
Mean	83·8 "	78·4 "

If we assume that the indications of the Prony dynamometer are reliable and that the loss in transmitting power between the Edison dynamometer and the arbor of the armature was only the same as the loss between the two dynamometers, the above numbers will have to be increased in the ratio of 100 to 93·2, and we shall have—

Total efficiency	89·9	per cent.
Available efficiency	84·1	"

These figures we believe fairly represent the performance of the machine in its present condition.

As points of excellence in the construction of this machine, we may mention the employment of large masses of iron for the field magnets; the breaking up of the armature core into thin plates, thus avoiding the expenditure of much useless

work; and finally, the almost entire absence of sparks at the commutator brushes, even when the machine is doing its maximum of duty.

Test of the Lamp.

The photometric tests were made by the well known method of Bunsen. The lamp, which was furnished us, was No. 853, one of the old pattern with carbon of charred paper, which had been used by Professors Rowland and Barker.

An arrangement was adopted by which the current employed, the difference of potential of the lamp wires and the resistance of the lamp could be measured, continuously, during the photometric observations. The current was measured by the deposition of copper in an electrolytic cell. The resistance was found by making the lamp one arm of a Wheatstone's bridge, suitably proportioned. The difference of potential was measured by a Thomson's high resistance galvanometer connected with the lamp terminals.

During the first test, which lasted twenty minutes, the mean photometric intensity "broad-side on" was 13·8 candles. Calculation shows the mean illumination to be about 73 per cent of the maximum, hence, the mean illumination was about 10·1 candles.

The resistance of the lamp, while shining, was found to be 99·6 ohms; and the difference of potentials at its terminals was 74·33 volts. (producing a current of 0·75 weber); hence the lamp was consuming 0·075 of a horse power. Or, adopting our previous result for the available efficiency of the dynamo-machine, we find that one horse-power *measured at the Edison dynamometer* would maintain a number of lamps represented by the formula $\frac{78 \cdot 4}{0 \cdot 075 \times 100} = 10 \cdot 5$, nearly.

During the second test, which lasted thirty minutes, the mean candle power of the lamp was 10·7 candles, calculated as before.

The resistance was	99·7 ohms.
The difference of potential	76·5 volts.
The current	0·76 weber.

Accordingly the lamp was consuming 0·077 of a horse-power —or one horse-power applied as before, would maintain 10·2 lamps at this candle power.

Taking the mean of these results we find that one horse-power *applied at the dynamometer* would produce in a lamp of this pattern and dimensions a light of 107 candles; or about 137 candles if we estimate the energy actually developed in the lamp in terms of horse-power.

Mr. Edison kindly put everything we required at our disposal, and himself, as well as Mr. Upton and his other assistants, aided us in every possible way.

ART. LXVI.—*On Substances possessing the Power of Developing the Latent Photographic Image;* by M. CAREY LEA, Philadelphia.

ABOUT three years since, I communicated to this Journal the results of a long series of studies on development. At the time when these were undertaken there were but four substances known to possess the power of development: ferrous sulphate, gallic acid, and pyrogallol, which had been long known to have this property, and hæmatoxyline, which I had some years before added to the number.

The studies made three years ago prove that the power of development, so far from being possessed by this small number of substances only, extends to a large number of chemical compounds, and is exhibited by many cuprous salts, by several vegetable acids, glucosides, etc. But the most curious result obtained was with ferrous salts. It was known that ferrous sulphate, though a powerful developer in the so-called "wet development," i. e., development in presence of a soluble silver salt, had no power whatever for those developments in which no soluble silver salt was present, and where the development was to be made at the expense of the film itself. I was able to show that ferrous oxide combined with almost any organic acid, possessed this power of forming a visible image at the expense of the film. So that a solution of ferrous sulphate by mixing with one of an alkaline oxalate, succinate, salicylate, etc., immediately acquires the power of development. Ferrous oxalate exhibits the power of development to a degree so remarkable that it seems likely to displace the older methods.

The study of the subject was resumed during the past winter, and with the result of ascertaining that this power of developing was not limited to the organic salts of ferrous oxide, but was possessed by many of its inorganic compounds. It certainly has never been suspected that such compounds as *ferrous phosphate*, *ferrous borate*, *ferrous sulphite*, *ferrous hypophosphite*, etc., possessed the power of development, but this they undoubtedly do, and not in any uncertain way. On the contrary, some of these compounds are among the most powerful of all known developing agents, equalling, or possibly even exceeding, ferrous oxalate in this respect, so that it is far from impossible that some of them may pass into technical use in preference to those now employed.

Some of these ferrous salts, especially the phosphate, sulphite and borate, are, like the oxalate, insoluble in water, and therefore need to be got into solution. As these salts are not, like the oxalate, soluble in the corresponding alkaline salt, at

least not to any useful extent, it becomes necessary to find an appropriate solvent. The most available solvents are solutions of ammonium and potassium oxalate, and of ammonium and sodium tartrate. Of these, the first have the material advantage that the ferrous salts remain permanently in solution, whereas with ammonium and sodium tartrate they are apt gradually to be precipitated.

As ferrous oxalate is a powerful developer, the question immediately presented itself whether the developing power exhibited, for instance by ferrous phosphate dissolved in ammonium oxalate might not be due to the formation of ferrous oxalate. But several reactions contradict this supposition. When a hot solution of ammonium (neutral) oxalate is fully saturated with ferrous phosphate, a precipitate separates in cooling, and this precipitate is not ferrous oxalate but ferrous phosphate. Again, ferrous phosphate exhibits powerful developing properties when dissolved in sodic or ammonic tartrate. This reaction is, however, not in itself decisive, inasmuch as I find that ferrous tartrate has itself developing properties. But as ferrous phosphate is to some extent soluble in a solution of ferrous sulphate, and as ferrous sulphate (in the form of development here under consideration, namely: in the absence of soluble silver salt) is wholly without developing power, an opportunity offered itself of testing the question. And it proved that a solution obtained by adding one of disodic phosphate to one of ferrous sulphate until a permanent precipitate began to form, undoubtedly possessed developing powers, though in a less degree.

The number of ferrous salts capable of developing the latent image is very considerable. Singular anomalies are often shown; a given salt prepared in one way may develop, while prepared in another it may have no such power. Nor is it possible to form an opinion beforehand as to whether a given compound of ferrous oxide will exhibit this power or not; compounds nearly allied do not exhibit analogies in this respect. For example: ferrous phosphate and ferrous metaphosphate are active developers, while ferrous pyrophosphate has no similar power.

Among other ferrous salts possessing more or less developing power, may be mentioned ferrous hyposulphite (hydrosulphate), ammonio-chloride, acetate, antimonio-tartrate, etc. Ferrous formiate, which might naturally be expected to be a powerful developer, is almost, though not entirely, destitute of the property. The most active agents found were ferrous borate, phosphate, sulphite and oxalate, respectively dissolved, the phosphate in neutral ammonium oxalate, the others in neutral potassium oxalate.

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the action of ethyl iodide on silver sulphite. The corresponding selenium compounds, treated in this way, afforded completely identical ethers both having the constitution $SeO\left\{\begin{matrix}OC_2H_5\\OC_2H_5\end{matrix}\right.$, and both affording selenous acid on decomposition with water. Selenous acid then is a true dihydroxyl acid $SeO\left\{\begin{matrix}OH\\OH\end{matrix}\right.$, and different from sulphurous acid.—*Ber. Berl. Chem. Ges.*, xiii, 656, April, 1880. G. F. B.

4. *On the Occurrence of Vanillin in Raw Beet Sugar.*—Certain samples of crude sugar prepared from the beet root, and especially those made by the maceration process, have been observed to possess a strong vanilla odor. SCHEIBLER has examined such sugars and finds that they contain a substance apparently identical with vanillin. To obtain it the sugar was extracted with ether in a percolator, the ether being repeatedly distilled through the mass. The ether extract, about 3·8 grams, was redissolved in ether, and the solution was allowed to evaporate spontaneously in a tall beaker. After some days, large, beautiful and nearly pure crystals formed at the bottom, while cauliflower-like efflorescences formed on the side of the vessel. After recrystallization, the crystals gave a strong vanilla odor, fused at 79° (uncorrected), sublimed to an oily liquid which solidified in radiating needles and behaved precisely like a sample of vanillin from Haarmann and Reimer's laboratory. The quantity was too small for an elementary analysis.

VON LIPPMANN, simultaneously but independently, has also isolated vanillin from raw beet sugar. Two kilograms of the sugar were dissolved in the minimum of water, the solution exactly neutralized with hydrochloric acid, and agitated with pure ether. After standing the ether was withdrawn by a separating funnel. By 170 of these extractions a sufficient quantity of material was obtained to examine. The residue was dissolved in as little ether as possible, and agitated with concentrated hydro-sodium sulphite solution. The solution thus obtained was treated with dilute sulphuric acid, the sulphurous oxide driven off by heat and the cooled liquid again extracted with ether. Oily drops were left on evaporation, but soon solidified. After purification, the substance was obtained as small pure white star-shaped groups of needles, possessing the odor and taste of vanilla. It was easily soluble in ether, alcohol, chloroform, and petroleum naphtha, difficultly in benzene and hot water, fused at 80°, and by careful heating sublimed undecomposed. Its solution reacted acid, reddened litmus, decomposed carbonates and reduced ammonical silver solutions on warming. Elementary analysis gave C 63·28 and H 5·58, the formula $C_8H_8O_3$ requiring 63·16 C and 5·26 H. Its identity with vanillin is therefore established.—*Ber. Berl. Chem. Ges.*, xiii, 335, 662, March, April, 1880. G. F. B.

5. *On the Conversion of Hyoscyamine into Atropine.*—It is a well-known fact that hyoscyamine splits up into hyoscinic acid

and hyoscine on boiling with hydrochloric acid; and also that atropine, thus treated, breaks up into tropic acid and tropine. Some time ago, LADENBURG called attention to the very close similarity between hyoscinic and tropic acids. He now shows that there is the same relation between hyoscine and tropine, these two bodies being identical. Their platinum chlorides have the same crystalline form, the free bases have the same boiling point, 229°, the same fusing point 62°, and they afford the same numbers on analysis. The curious fact now appeared that two isomeric alkaloids gave identical decomposition products. To test the matter synthetically three experiments were made: (1) Tropine from atropine and hyoscinic acid from daturine were treated with hydrochloric acid on the water bath; (2) Hyoscine from hyoscyamine and tropic acid from atropine were thus treated; and (3) Hyoscine from hyoscyamine and hyoscinic acid from hyoscyamine, were also treated in the same way. The residue, after neutralization and extraction with alcohol, was dissolved in hydrochloric acid, and precipitated with gold chloride. In each case atropine-gold chloride was the product; thus proving the identity of their decomposition products and establishing the conversion of hyoscyamine into atropine.—*Ber. Berl. Chem. Ges.*, xiii, 607, April, 1880. G. F. B.

6. *On the Product of the Oxidation of Albumin by Permanganate.*—The question whether by the direct oxidation of albumin, urea is produced, has been an open one. LOSSEN has now repeated with care the experiments of Béchamp and others, 500 grams of purified egg-albumin being diffused in 400 c.c. of water containing 30 grams potassium hydrate, the equivalent quantity of magnesium sulphate being added, and then 375 grams $K_2Mn_2O_7$ and 294 grams of the sulphate put in gradually. From the liquid a crystalline substance was obtained which at first was supposed to be urea, but which proved to be guanidine. No urea whatever could be detected.—*Liebig's Annalen*, cci, 369, Feb., 1880. G. F. B.

7. *On Maxwell's Theory of Light.*—The author, J. G. THOMSON, reviews the results which are contained in Prof. Maxwell's treatise on Electricity and Magnetism, and adds a discussion of his own upon the interpretation of the equations given by Maxwell when they are modified to embrace the new condition of a motion of the medium through which the light passes. Suppose that the dielectric moves with a velocity u in the direction of the propagation of the light. Let V be the velocity of propagation of light in the dielectric when it is at rest; the author finds $\frac{q}{p} = \frac{u}{z} + V$ approximately. In which $\frac{q}{p}$ is the velocity of propagation of light in the medium. The conclusion is, therefore, drawn that the velocity of the light is increased by one-half the velocity of the dielectric.—*Phil. Mag.*, April, 1880, p. 284. J. T.

8. *Suggestions in regard to Crystallization.*—Mr. S. TOLVER PRESTON discusses crystallization under the following assumptions:

1. Molecules are elastic. 2. Molecules possess an open structure. 3. The ether is a gas whose atoms are so small that their mean length of path is greater than any planetary distance. The motion of these atoms produces the phenomena of gravitation on Le Sage's principle.

Various crystalline forms are regarded as due to the yielding of the ultimate particles of matter under different conditions of stress and strain; and the conception of elastic molecules is contrasted with that of infinitely hard molecules.—*Phil. Mag.*, April, 1880, p. 267. J. T.

9. *Solubility of Gases in Solids.*—Messrs. HANNAY and HOGARTH have experimented upon this subject with the following modifications of Andrews' apparatus: "a T-tube of wrought iron, one-half inch internal and one inch external diameter, was furnished with wrought iron screw cups. Through one of these the pressure screw works; through the opposite end the experimental tube is fixed. The side branch, about three inches long admitted an air manometer. The apparatus, which was less than twelve inches in length, was filled with mercury." The packing consisted of India rubber plugs covered with greased leather, through which the pressure screw passed. At high pressure the tube was cemented with oxychloride of zinc. This simple method of packing gave freedom of motion at the pressure, even, of 880 atmospheres. With this apparatus various crystals dissolved in alcohol gas, and the authors obtained solutions of sulphur, selenium, and arsenic in bisulphide of carbon, in a more or less conclusive manner. The authors conclude that the critical point of a gas is altered by having a solid dissolved in it, and claim that, since their experiments were made at temperatures much more remote from the critical point than those of Andrews, they have given still further evidence of the continuity of the liquid and gaseous states.—*Nature*, March 25, 1880. J. T.

10. *Chemical Affinity in terms of Electromotive Force.*—Dr. WRIGHT reviews the work of Joule and others upon the Mechanical Equivalent of the operation of Electrolysis, and is led to a discussion of the various results obtained for Joule's equivalent and for the value of the ohm; and states that he is about to communicate results of measurement of the mechanical equivalent of heat which are based upon an electrical method.—*Phil. Mag.*, April, 1880, p. 237. J. T.

11. *Velocity of Electricity in the Electric Current.*—BOLTZMANN discusses the new discovery in magnetism made by Mr. E. H. Hall, of the Johns Hopkins University, and shows that the absolute velocity of a current of electricity in a conductor can be determined by the employment of the method described by Hall. It is also shown that the general equations of Kirchhoff, Weber, Helmholtz, Maxwell and Stefan for the motion of electricity in conductors should be modified so as to embrace a new term which expresses the electro-dynamic action discovered by Hall.—*Kais. Akad. der Wiss. in Wien*, Jan. 15, 1880, p. 11. J. T.

12. ***Measurements of Gravity at Initial Stations in America and Europe.*** 145 pp. 4to. Washington, 1879. (U. S. Coast Survey, C. P. Patterson, Superintendent. Methods and Results—Appendix No. 15, Report of 1876.)—This paper forms the first part of the report by Mr. C. S. Peirce on the measurement of the acceleration of gravity at initial stations in America and Europe. It includes the discussion of the observations made with a Bessel reversible pendulum and of the large number of corrections required in obtaining the true result. The observations were obtained with the same pendulum, swung at the following stastations: Geneva, Paris, Berlin, Kew and Hoboken. By this means the observations in America are connected immediately with those of the most important stations abroad, where the chief absolute determinations have been made and from which pendulum expeditions have been sent out. The station at Hoboken thus becomes the initial station for this continent. Similar action has been in part followed by European surveys, Switzerland and Austria having already swung their standard pendulums at Berlin; this is in compliance with the plan adopted at the meeting of the International Geodetic Congress in Paris in 1875.

II. GEOLOGY AND MINERALOGY.

1. *Geological Survey of Pennsylvania. The Permian or Upper Carboniferous Flora of West Virginia and Southwest Pennsylvania;* by WM. A. FONTAINE, Prof. Geol. Univ. of Virginia, and I. C. WHITE, Professor Nat. Hist. Univ. West Virginia and Assistant Geologist on the Geological Survey of Pennsylvania. 144 pp. 8vo, with 38 plates.—The authors derive, from the study of the plants of the "Upper Barren" Coal Measures of Pennsylvania and Virginia, that this part of the so-called Carboniferous formation, is Permian in its relations. The species determined belong to the genera *Equisetites*, *Calamites*, *Nematophyllum*, *Sphenophyllum*, *Annularia*, *Sphenopteris*, *Neuropteris*, *Odontopteris*, *Callipteris*, *Callipteridium*, *Pecopteris*, *Goniopteris*, *Cymoglossa*, *Alethopteris*, *Tæniopteris*, *Rhacophyllum*, *Caulopteris*, *Sigillaria* (two species), *Cordaites*, *Rhabdocarpus*, *Carpolithes*, *Gulielmites*, *Saportæa*, *Baiera*. The following are part of the proofs of Permian age which the authors present. Out of 107 species found in the Upper Barrens of West Virginia, 22 occur in the Coal Measures proper, while 28 (including 16 of the preceding 22) are European Permian species. Of the 28, 12 have never been found in the Coal Measures of the United States, and two, *Callipteris conferta* and *Alethopteris gigas*, are exclusively Permian. Again, *Odontopteris obtusiloba* is a characteristic Permian plant. The genus *Baiera*, which first appears abroad in the Permian, has a species *B. Virginiana*, differing chiefly in greater size and robustness from the Permian *B. digitata*. There are no *Lepidodendra*. *Alethopterids* and *Odontopterids* are rare (two of the former and four of the latter); nearly all the *Pecopterids* have the arborescent character which characterizes Permian

species; and the *Neuropterids* and *Sphenopterids* show Permian features. Further, the occurrence of Conifers of the genus *Saportæa*, allied to *Salisburia*, favors the view sustained, as this type which made its appearance in the Permian, has great prominence in the Jurassic.

The evidence from the animal fossils is feeble, as there is little of it, but none opposes the idea of a Permian age.

Above the Pittsburg Coal, and its associate coals, the Redstone and Sewickley there are two marked stratigraphical horizons. One is that of the limestones between the Sewickley and Waynesburg coal-beds; in the shales accompanying the latter there occur nearly all the characteristic Carboniferous plants of the Upper Barrens, but mixed with many new forms. The other is that of the overlying Waynesburg sandstone, much of it very pebbly. Only about twenty per cent of the species existing below this sandstone pass above it; and coal-beds become very thin above and gradually disappear. "This is what we should expect *a priori* if we should regard the Permian, not as a distinct formation, but as the close of the Carboniferous," as sustained by "the investigations of Weiss, Grand 'Eury and others." The first of the above horizons marks the transitions from the Carboniferous to the Permian.

The conclusion of the authors appears to be well sustained; and, as they state, it places the "great Appalachian Revolution" "at the close of the Permian Period" and explains "the absence of Permian beds from the Mesozoic areas of the eastern portion of the Continent and the Triassic age of the oldest beds there found."

2. *Geology of Wisconsin:* Survey of 1873 to 1879. Vol. III, accompanied by an Atlas of Maps. Published under the direction of the Chief Geologist, J. C. Chamberlin, by the Commissioners of Public Printing. 764 pp., 8vo, with many plates, maps and sections. 1880.—This volume of the final report on the Geology of Wisconsin treats of the general geology of the Lake Superior region, including Northern Wisconsin, and then, in its several chapters, of the topography, special geology and lithology. The rocks, with the exception of the Cambrian beds, are referred to the Laurentian, the Huronian and the Keweenawan or Copper-bearing systems, and the last, as well as the others, is made pre-Cambrian. Professor R. D. Irving reports on the general geology, and geology of the Eastern Lake Superior district; R. Pumpelly, on the lithology of the Keweenawan system; A. A. Julien, on some rocks of Ashland County; C. E. Wright, on the Huronian series of Penokee Gap, (including the Penokee iron range) and on the Menominee iron region; E. T. Sweet, on the Western Lake Superior district; T. C. Chamberlin, on the Upper St. Croix district, from the notes of the late Moses Strong; T. B. Brooks, on the Menominee region; A. Wichmann, on the microscopic character of the Huronian rocks of the Iron region. The volume contains many maps, sections

and plates on microscopic lithology, distributed through the text, and is accompanied by an atlas of large, colored, geological maps. It bears evidence throughout of careful study. It is especially important for its illustrations of Archæan formations; its detailed lithological descriptions of the various crystalline rocks, based largely on microscopic investigations; and, economically, for its reports on the iron ore regions and their ores and mines, and on the Keweenaw copper region. It also contains various observations on Quarternary deposits, terraces and erosion.

3. *Palæontology of New York.* Vol. V. Part 2, containing descriptions of the Gasteropoda, Pteropoda and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups, by JAMES HALL, State Geologist. Text, 492 pp. 4to, with a 4to volume of 120 lithographic plates. Albany, N. Y. 1879.—This new volume of Prof. Hall's great work will be gladly welcomed by all students in American Paleontology. Albertypes from the drawings of a large part of the plates, together with others of Crustacea, 130 in all, were issued, without descriptions, in a volume in 1877, and a notice of the same was given in volume xiv of this Journal (p. 493).

This *second* part of volume V, now published, will soon be followed by Part I, which treats of the Lamellibranchiata; 80 plates have already been printed. The preface to the volume also states that the descriptions and plates of the Corals, Bryozoans, Brachiopods and Crustaceans of the Upper Helderberg and Hamilton groups are far advanced, over 60 plates illustrating these subjects being finished and a large part already printed. Besides, the manuscript of the Corals and Bryozoa of the Lower Helderberg is ready, and the twenty-two plates are completed and printed. Further, over 800 other drawings of corals have been made for the final illustration of this class of fossils. These statements show that great progress has been made toward the completion of the New York Paleontology.

4. *Report on the Geological Survey of New Jersey for the year* 1879; by the State Geologist, Professor G. H. COOK.—This report contains new facts relative to some of the geological formations of New Jersey, and also with regard to the iron ores, soils, clays, waters, and other points of economical importance. It states that the number of opened mines of magnetite in the New Jersey Archæan is now nearly 200, and that they could supply a million of tons annually. The Triassic formation at the Belleville quarries has afforded remains (the "decorticated trunk") of a fossil plant which, according to Professor Lesquereux, resemble much the *Lepidodendron Weltheimianum*, a species of the Devonian and Subcarboniferous. Very positive evidence will be required to make it certain that it is this old species, or any species of *Lepidodendron*. Professor Cook states that the sandstone of the "southeastern margin of the formation contains mostly grains of feldspar instead of quartz," as if made from a very feldspathic gneiss or granite, such as is found in great quantities on that side

of the formation; "while the rock of the northwestern side contains fragments of magnesian limestone," a rock occurring in the older formations near by on that side. The exposure of Silurian magnesian limestone within the area of the sandstone, and other facts are stated to favor the view of a comparatively small thickness for the formation.

The report is accompanied by a handsome colored geological map of the State.

5. *Note on the occurrence of fossils in the Triassic and Jurassic beds near San Miguel in Colorado;* by R. C. HILLS.—The fossiliferous portion of the Triassico-Jurassic beds of the Upper San Miguel is situated in lat. 37° 58′ N., long. 107° 50′ W., near the town of San Miguel city, and extends east from that point along the flank of San Miguel park about two and a half miles. The fossils occur in the upper portion of the red sandstone beds and are confined to two strata, aggregating about fifty feet in thickness. The lower stratum, in which the Pterophyllum was found, is a fine-grained micaceous red sandstone with a schistose cleavage. It often shows mud-cracks and raindrop pits, also casts, such as might be caused by a large animal reclining upon moist sandy material.

The upper stratum is made up of small pebbles mostly calcareous. Fragments of teeth are very abundant in this stratum, with an occasional fragment of bone and short flattened tree trunks showing upon the surface numerous small warty protuberances and right lines from one and a half inches to two inches apart. These trunks are from three feet to five feet long and taper rapidly from the base. Fishes near *Belodon priscus* and *Catopterus gracilis* occur in this stratum; but, as the coarse material of which it is composed is not adapted to receive and retain delicate impressions of perishable forms, the occurrence of the last named fossil will probably be restricted to places where small depressions favored the deposition of finer sediment. This bed underlies and is conformable with a second series of rocks having from twenty feet to forty feet of bituminiferous limestone at the base, followed by a few feet of hornstone and several hundred feet of gray sandstone. I have not observed any fossils in this series, which is unconformable with the Cretaceous and may be Jurassic. As might be expected, a thin stratum of white sandstone underlies, in some places, the bitumeniferous limestone.

The rock of the lower portion of the red sandstone series are often shaly and readily separable into fragments of conchoidal fracture.

The erosion has not been sufficient to reveal the thickness of these beds, but it is not less than 1,000 feet.

A good section of these rocks is showed upon the Animas where they extend for six miles along the river between Hermosa and Animas City, upon the Dolores near Rico, on the Uncompahgre below Ouray and less extensively on nearly every stream tributary to the Animas and San Juan.

6. *Note on Sauranodon;* by O. C. MARSH.—The name Sauranodon, given by the writer to a genus of Jurassic reptiles, appears to have been previously used in the same class by Jourdan. If thus preoccupied, it may be replaced by the name *Baptanodon*, for the extinct generic form, with *Baptanodontidæ* for the family, and *Baptanodonta*, for the Suborder represented.

May 20, 1880.

III. BOTANY AND ZOOLOGY.

1. *Revision of the Genus Pinus, and Description of P. Elliottii;* by Dr. GEORGE ENGELMANN. St. Louis, 1880. Separately issued from the Transactions of the Academy of Science of St. Louis, vol. iv, no. 1, pp. 161–190 (1–30), but printed in folio, to match the plates, 1–3.—The plates, illustrating *Pinus Elliottii* Engelm., are very fine, having been excellently drawn from nature on stone by Paul Roetter, and they give the whole port, structure and germination of this the handsomest species of our Atlantic States. In appearance it is as it were intermediate between *P. Tæda* and *P. australis*. The characters of the Pines and a sketch of former arrangements are surveyed in detail; the anatomy of the leaves is particularly attended to, and the character of the resin-ducts is turned to account as a very important subsidiary mark of affinity. The primary sections of the genus are reduced to two, founded mainly on obvious differences in the scales of the cones, viz: *Strobus*, with marginal unarmed umbo (divided into *Eustrobi* and *Cembræ*), and *Pinaster*, with dorsal and mostly armed umbo. Then the subdivisions are distinguished by the position of the ducts within the leaf, "whether peripheral, parenchymatous, or internal;" then the position of the female ament and cone, whether subterminal or lateral; and finally the number of leaves in the fascicle is taken into consideration in the second section; the first consisting wholly of five-leaved species. Although only such species and subspecies are enumerated as the author has himself examined, yet the list is almost complete.

P. albicaulis of California is reduced to a subspecies of *P. flexilis*, a marked one certainly, as to the cones; and *P. Balfouriana* of California (now re-discovered on the slope of Shasta) is considered to include the Rocky Mountain *P. aristata*. *P. ponderosa*, after long study, is still left to include extreme forms. *P. Banksiana*, being a year earlier than the name *P. rupestris* of Poiret, is retained for the species. A second Cuban species is characterized from C. Wright's collections, and is named *P. Wrightii*, but male flowers have not been seen. It is suggested that the fine *P. Elliottii*, here so admirably illustrated, may not be wholly distinct from *P. Cubensis*.

The size of the pollen-grains is given for most of our species. Their lightness and power of floating a long time in the air, and therefore of transportation by the wind, are shown in the statement that pine-pollen has been found in the streets of St. Louis, after

a rain-storm from the south, in March, when no pines north of Louisiana were in bloom, and which must have come from the forests of long-leafed pine on Red River, over about 6½ degrees of latitude or 400 miles in a direct line. Let us congratulate Dr. Engelmann upon his satisfactory completion of his prolonged investigation of our *Coniferæ*. A. G.

2. *Methodik der Speciesbeschreibung, und Rubus: Monographie der einfachblättrigen und krautigen Brombeeren*, etc. . . . von Dr. OTTO KUNTZE. Leipzig, Felix, 1879. 160 pp. 4to, with a lithographic plate and seven statistic-phytographical tables.—A most elaborate discussion, first of the diversity of value and indefiniteness of botanical species, followed by a plan for a better presentation of botanical relationship; next an application of the new "speciesbeschreibung" to the simple-leaved *Rubi*. The author sets out with the proposition—in one sense true—that Darwin on one hand and Jordan on the other have shattered to the foundation the Linnæan conception of species; but that this conception still fetters systematic botany; that the plan of describing only typical forms, or what we choose to consider such, is a deliberate negation of existing facts; and that to follow the rules of arranging related forms under the successive stages of species, subspecies, varieties, subvarieties, etc., has become incompatible with a strict and faithful following of nature. He insists that the monographer should describe all the forms, and arrange them according to their relationship, which arrangement, if successful and true, will bring to view their probable genealogy.

Rosa, *Rubus*, and *Hieracium* in the Old World, *Lupinus* and *Potentilla* in North America, are among the genera which countenance this view, and are the despair of systematists. If most botanical genera were like them, we should all be driven to conclusions like those which Dr. Kuntze perhaps too hastily or too absolutely propounds. But in our opinion, the Linnæan conception and the Linnæan practical treatment of species are quite capable of being worked with advantage and fair success under the idea of relative instead of absolute fixity of character; and we are confident that, if abandoned, we shall not in our day find anything so good to put in their place. We seem to need re-adaptation rather than reconstruction; and we fear that Dr. Kuntze's plan of treatment will diffuse the difficulties over a wider surface rather than obviate them. Of course the idea of disposing the forms according to supposed genetic relationship is most proper and scientific; but that is the attempt and ultimate aim now-a-days in all natural history; and so far as it can be done at all, may be as well accomplished under the received taxonomy as under our author's scheme. Not that we would depreciate the value of such a treatment as he has given to a part of the genus *Rubus*, or doubt that "collective species" may be advantageously so discussed, in spite of the formidable number of confessedly indefinite terms which are found necessary.

For example, to designate grades of forms in this genus, we have

first a general division into *Finiformes* and *Gregiformes;* the former being those which appear to have no very near surviving relatives, i. e. they are very well marked and moderately varying species. Those with numerous variations within a common type are *Gregiformes;* and these again may be distinguished as *Lovo-formes*, *Typiformes*, *Versiformes*, *Ramiformes*, *Avoformes*, *Medio-formes*, *Mistoformes*, *Singuliformes*, and a few more,—terms which we have not space to define, which indeed are not to be really defined, and nearly all of which involve hypotheses. An application of them is seen in the suggested derivation of *Dali-barda repens* from *Rubus nivalis!*

Moreover, Dr. Kuntze proposes to use arbitrary signs in place of language in botanical descriptions, which give to botanical characters the aspect of mathematical formulæ. To us all this is most repulsive. In the preface botanists are requested, in case they do not approve these schemes, to turn their endeavors towards bettering them. But as yet they are hardly shut up to the alternative. Slight betterments of the old paths from time to time, as need appears, may be more serviceable than doubtful labor upon new and untrodden roads. A. G.

3. Charles Christopher Frost, the oldest cryptogamist in this country, died at Brattleboro, Vermont, March 16, 1880. He was born in the same town Nov. 11, 1805, and lived there throughout his long life. His father was a shoemaker, which trade his son learned in his youth, afterward becoming a dealer in boots and shoes, and he continued in this business until his death. He received a common country-school education; but in the leisure hours snatched from his business, he devoted himself to scientific pursuits and mastered, unaided, the Latin, French, and German languages, for the purpose of studying works upon Natural History. He was a born naturalist, loving Nature for herself and not for the fame or position he might attain by the publication of his investigations. There was scarcely a branch of scientific study which he did not pursue to some extent. He explored the country about him exhaustively, collecting everything in the domain of natural science; but he was best known to the world as a student of Cryptogamic Botany, and was a life-long correspondent of the celebrated cryptogamists of his time. He amassed a large collection of species of natural history and was the author of numerous species in his favorite specialty, the Fungi. He communicated various papers to the publications of his day; but his most important contribution to science is a List of the Mosses, Liverworts, Charas, and Fungi, in the "Catalogue of plants growing within thirty miles of Amherst," published by Professor Edward Tuckerman and himself in 1875. C. J. S.

III. ASTRONOMY.

1. *Elements of the Comet discovered by J. M. Schæberle at the Ann Arbor Observatory on the 6th of April.* Letter to the editors from Mr. SCHÆBERLE, dated Ann Arbor, Mich., May 18, 1880.—As there is no ephemeris published of the comet which I discovered on April 6, and as it is quite probable that observations can still be made with large instruments, as soon as the moon gets out of the way, I send you the ephemeris below for publication in the American Journal of Science.

An approximate orbit was first computed from Ann Arbor observations of April 6th, 12th and 20th. The large perihelion distance as shown by the resulting elements induced me to lengthen the interval of time between the extreme dates. An orbit was then computed from the following data; the times of observation and the places of the comet being corrected for aberration and parallax respectively:

	Ann Arbor Mean Time.	App. α.	App. δ.
April 6, 1880,	$15^h\ 56^m\ 30^s$	$7^h\ 12^m\ 30^s{\cdot}40$	$84^\circ\ 24'\ 2''{\cdot}1$
April 20, 1880,	11 52 11	6 16 37·65	73 51 59·3
May 4, 1880,	9 14 11	6 15 47·66	64 55 27·3

The resulting elements I find to be

$$T = \text{June } 30{\cdot}7964 \text{ Washington mean Time.}$$

$$\left.\begin{aligned}\pi &= 41^\circ\ 51'\ 27''{\cdot}8\\ \Omega &= 257\ \ 9\ \ 48{\cdot}5\\ i &= 123\ \ 5\ \ 29{\cdot}8\end{aligned}\right\}\text{Ecliptic and mean Equinox } 1880{\cdot}0.$$

$$\log q = 0{\cdot}259736$$

	Co.—Ob.	
The residuals for the middle place are	$\Delta\lambda \cos\beta$	$\Delta\beta$
	$-1''{\cdot}9$	$-3''{\cdot}9$

Ephemeris for Washington Mean Midnight.

1880.	App. α.	App. δ.	log. γ.	log. Δ.	Intens'y of light
May 24.5	$6^h\ 25^m\ 9^s$	$54^\circ\ 51'{\cdot}4$	0·27404	0·39795	0·79
28.5	6 27 23	53 10·4	0·27132	0·40503	0·77
June 1.5	6 29 39	51 34·5	0·26869	0·41154	0·76
5.5	6 31 56	50 3·2	0·26645	0·41746	0·75
9.5	6 34 12	48 36·1	0·26452	0·42276	0·74
13.5	6 36 27	47 12·7	0·26291	0·42740	0·73
17.5	6 38 39	45 52·6	0·26162	0·43138	0·72
21.5	6 40 47	44 35·5	0·26066	0·43469	0·71

The corrections to the times, for aberration, are still to be applied. The intensity of the light of comet for April 6, is taken as the unit of measure. The R.As. will probably not be more than a second or two in error. The declinations may require a correction of two or three minutes of arc, toward the close of the ephemeris. The declinations deduced from the elements of the orbit given in the Circular of the K. K. Ak. in Wien, are largely in error. On May 12 the ephemeris was nearly half a degree out in declination, so that I felt warranted in sending you the ephemeris given above.

IV. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The following is a list of papers registered and read at the meeting of the National Academy of Sciences, at Washington, April 20–23, 1880.

Joseph LeConte.—Binocular Vision; Laws of Ocular Motion.

W. Ferrel.—1. Hollow Water-Spouts and Sand-Spouts. 2. Cloud-Bursts.

E. D. Cope.—1. On the Structure of the Vertebrata of the Permian Period.—2. On the Perforations of the Squamosal bone of the Mammalia.

Elias Loomis.—Contributions to Meteorology.

A. S. Packard.—On the Structure of the Brain of Limulus polyphemus.

S. P. Langley.—1. On an Instrument for Measuring Radiant Heat.—2. On the Composition of Colors.

Alexander Agassiz.—The Sea Urchins of the Challenger Expedition.

O. C. Marsh.—Size of the Brain in Extinct Animals.

W. Gibbs.—On New Complex Inorganic Acids.

T. Sterry Hunt.—On the Taconic System in Geology.

F. M. Green, U. S. N.—On the Telegraphic Determinations of Longitude by the U. S. Hydrographic Office.

D. P. Todd.—On the Announcement of the Discoveries of Intra-Mercurial Planets by Telegraph.

Wm. Harkness.—On the Solar Corona.

E. S. Holden.—On the Nebula of Orion.

Theo. N. Gill.—On the Distribution of the Zenopsis Conchifera.

Josiah P. Cooke.—Revision of the Atomic Weight of Antimony.

Cleveland Abbe—Application of Meteorology to the Grasshopper Pest.

Edward S. Morse.—On an Early Race of Man in Japan.

H. M. Paul.—On the effect of railroad trains in transmitting vibrations through the ground as regards its effect on observations in fixed observatories.

Albert A. Michelson.—On the modifications suffered by Light on passing through a very narrow slit.

J. Lawrence Smith—Some remarks on the supposed nature of the Sun's Corona; and, also, On a supposed new Meteoric silicate.

Stephen Alexander.—On some modern developments bearing upon the Nebular Hypothesis and other matters connected therewith, as well as on some previous changes, and miscellaneous notices.

2. *Emmet County Meteorite:* Supplement to the article on page 459, by the author, J. Lawrence Smith.—When my paper was sent to press, the following new facts in connection with this meteoritic fall had not been discovered. I am indebted for them to Mr. Chas. Birge. These additional discoveries, twelve months after the fall, only add to the interest of this phenomenon. Mr. Birge, a few months ago, had been made aware of the fact that a number of boys, herding cattle near a lake about four miles west of Estherville on the day of the fall, reported that when the meteor passed over them, a great shower of what appeared to them hailstones fell, and that the surface of the water was alive with the falling bodies. Three weeks ago (April 15th) the people of that neighborhood began to find, on the freshly burnt prairies, small pieces of meteorites from the size of a pea to one pound in weight; 300 to 500 were thus found; and ten days ago (May 1st) thousands of men, women and children were on the ground daily, and from the meteoric field probably five thousand pieces have already been gathered, making in all a weight of not less than from 60 to 75 pounds.

3. *Statistics on Earthquakes;* by Professor C. G. ROCKWOOD, Jr. (Communicated.)—Professor Dr. C. W. Fuchs, formerly of Heidelberg, but now in Meran, Tirol, Austria, has for the last fifteen years published annual statistics of earthquakes and volcanic phenomena, and has noticed that in his lists America is remarkable for the paucity of shocks reported. This he attributes, and we think rightly, to the lack of information on the subject, rather than to any real scarcity of such events. As he is now proposing to revise his lists, he has presented to the Smithsonian Institution a request for information in regard to American earthquakes, especially for the whole or any part of the period since 1865. He would be thankful for any information on the subject which may be in the possession of American observers, and which may be sent to his address as above.

The undersigned, who has for the past eight years been occupied in a similar work in America, would take this opportunity to say to the readers of the Journal, that he also would be very glad to come into communication with other workers in the field of Seismology, either American or foreign. He is especially desirous to obtain correspondents upon the Pacific Coast, who would aid in collecting information in regard to earthquake shocks in that region, where they are so much more frequent than on the Atlantic seaboard.

Princeton, N. J., May 12, 1880.

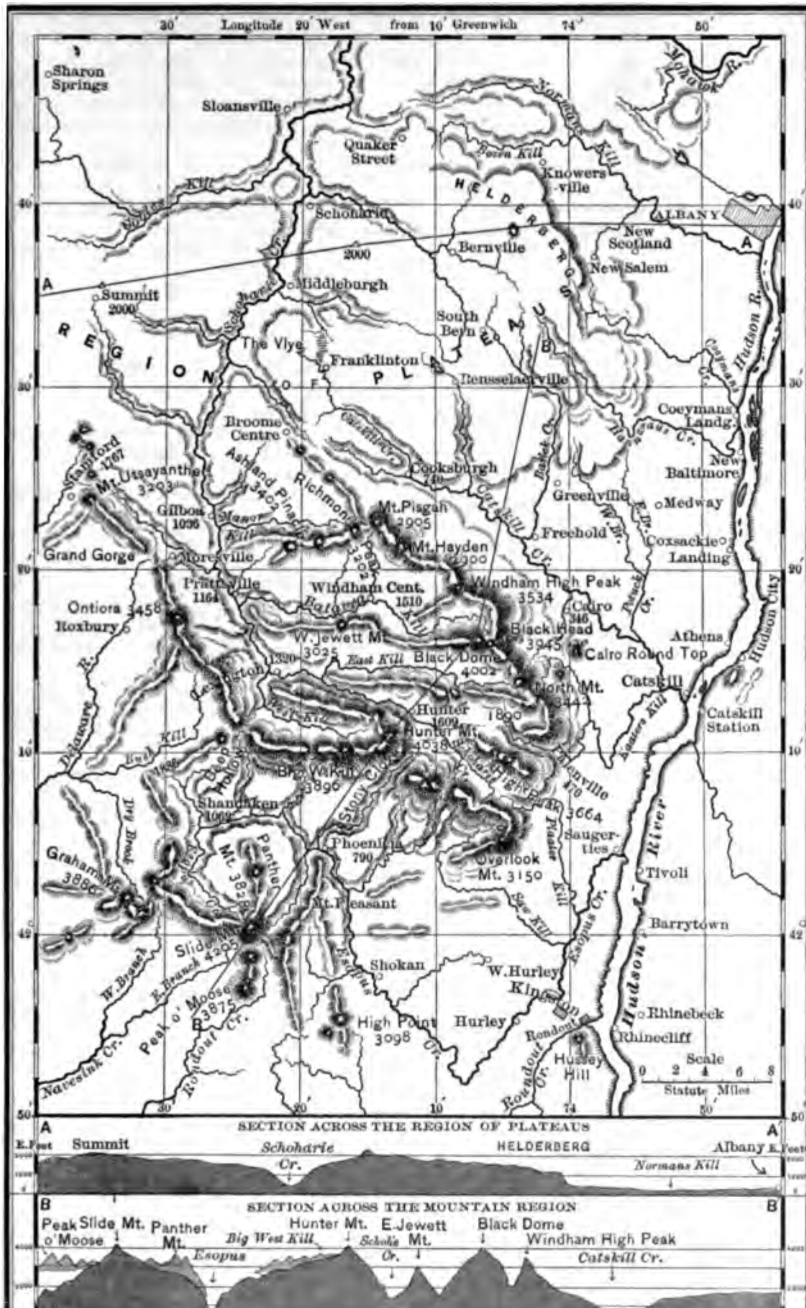
4. *Tables of the Common Logarithms and Trigonometrical Functions to Six Places of Decimals. With special regard to their Use in Schools.* Edited by Dr. C. BREMIKER. 517 pp. 8vo. New York, 1880. (B. Westermann & Co.).—This reprint of Bremiker's well-known tables is perhaps the very best which has been made accessible to the non-mathematical, scientific and popular public. The arrangement of the figures on the page, both as respects spacing and amount, is that which most quickly guides the eye and conduces to facility in use. The arguments of the logarithms of numbers are given directly to five figures, and the arguments in arc of the trigonometrical functions are given to ten seconds. In both of these respects the tables are superior to those found in current use among the students in our country. Another excellent feature is the addition of a table of Gauss's Logarithms—which would be more widely used if good tables of them were commonly found. The work, both on account of its high reputation for accuracy and its compact convenience, deserves a wider use than it has yet obtained among the very considerable class of students and professional men who have computing to do, but who use inferior tables, or none at all. L. W.

OBITUARY.

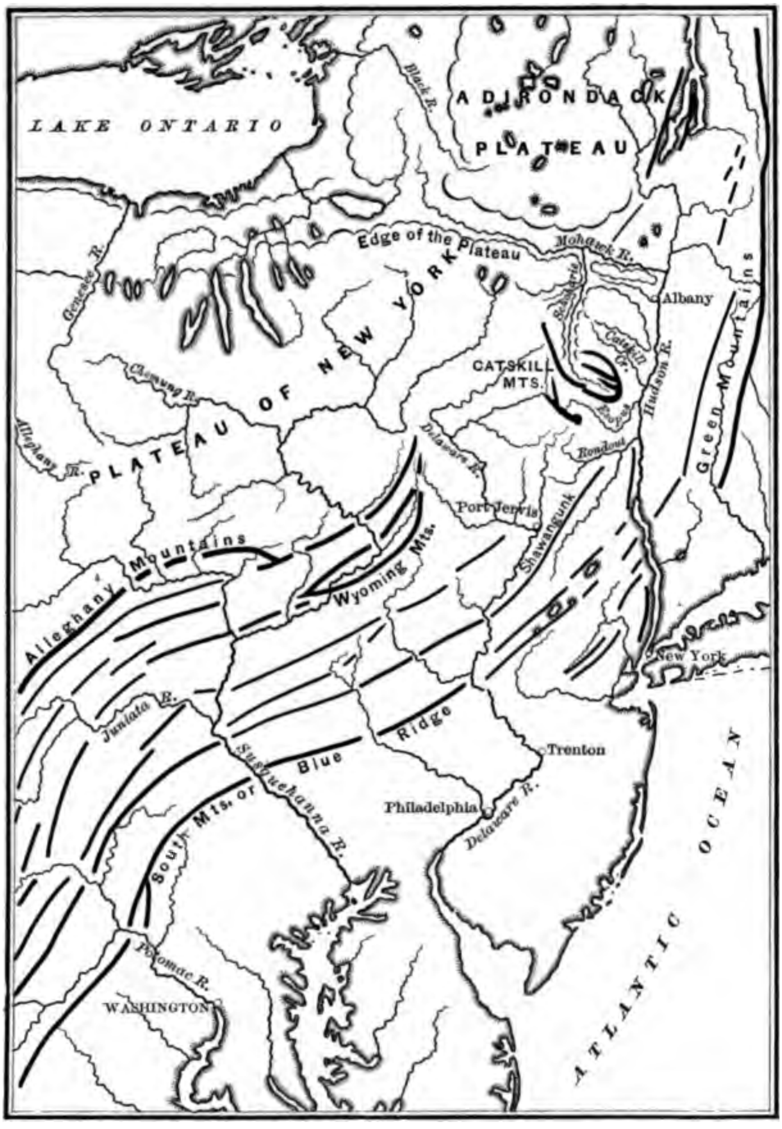
Professor WILLIAM H. MILLER, the eminent Crystallographer and Mineralogist of Cambridge, England, has recently died, at the age of seventy-nine.

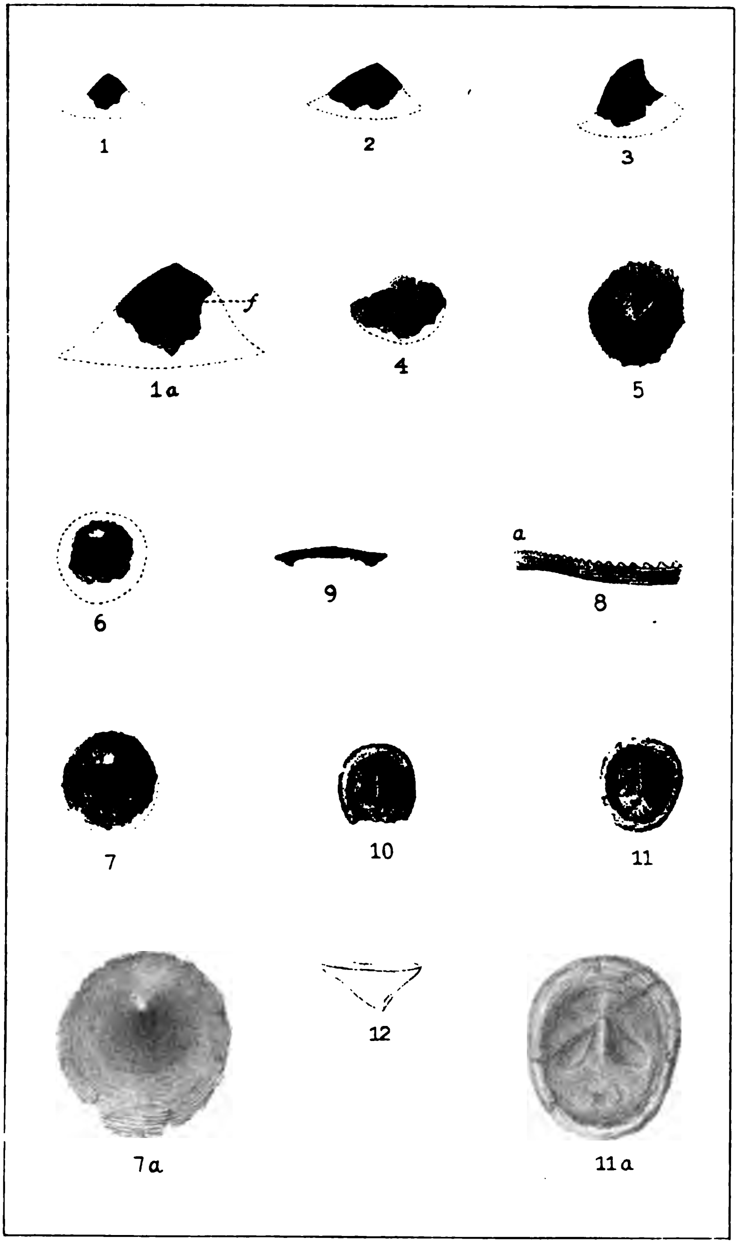
INDEX TO VOLUME XIX.*

* This Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, OBITUARY, ZOOLOGY, and under each the titles o Articles referring thereto are mentioned.


Longitude 20' West from 10' Greenwich
Sharon Springs
Sloansville
Quaker Street
Knowers -ville
HELDERBERGS
ALBANY
Schoharie
Berneville
New Scotland
New Salem
Summit 2000
Middleburgh
REGION OF PLATEAUS
The Vlye
Franklinton
South Bern
Rensselaerville
Hudson R.
Coeymans Landg.
Broome Centre
Cooksburgh
New Baltimore
Stamford 1767
Mt. Utsayanthe 3203
Gilboa 1036
Mt. Pisgah 2905
Greenville
Medway
Mt. Hayden 3000
Freehold
Coxsackie Landing
Grand Gorge
Moresville
Prattsville 1164
Windham Cent. 1510
Windham High Peak 3534
Cairo
Ontiora 3458
Roxbury
W. Jewett Mt. 3025
Black Head 3945
Athens
East Kill
Black Dome 4002
Cairo Round Top
Hudson City
North Mt. 3443
Catskill
Hunter 1609
Catskill Station
Hunter Mt. 4038
Delaware R.
Big W. Kill 3896
Shandaken 1069
High Peak 3664
Saugerties
Phoenicia 790
Panther Mt. 3828
Graham Mt. 3886
Overlook Mt. 3150
Tivoli
Hudson River
Mt. Pleasant
Barrytown
Slide Mt. 4205
Shokan
W. Hurley
Kingston
Peak o' Moose 3875
High Point 3098
Hurley
Rhinebeck
Rhinecliff
Rondout
Hussey Hill
Scale
0 2 4 6 8
Statute Miles
SECTION ACROSS THE REGION OF PLATEAUS
Summit
Schoharie Cr.
HELDERBERG
Albany
Normans Kill
SECTION ACROSS THE MOUNTAIN REGION
Peak o'Moose
Slide Mt.
Panther Mt.
Big West Kill
Esopus
Hunter Mt.
E. Jewett Mt.
Black Dome
Windham High Peak
Catskill Cr.

E. Sondes del.


LAKE ONTARIO
Black R.
ADIRONDACK
PLATEAU
Edge of the Plateau
Mohawk R.
Genesee R.
Albany
PLATEAU OF NEW YORK
Schoharie
Catskill Cr.
CATSKILL MTS.
Hudson R.
Esopus
Chemung R.
Alleghany R.
Delaware R.
Rondout
Green Mountains
Port Jervis
Shawangunk
Alleghany Mountains
Wyoming Mts.
New York
Juniata R.
Blue Ridge
Trenton
Susquehanna R.
South Mts. or
Philadelphia
Delaware R.
ATLANTIC OCEAN
Potomac R.
WASHINGTON



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